County of Santa Clara
Department of Parks and Recreation
Trail Maintenance Guidelines

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Trail Maintenance Manual

Prepared By:

Greg Bringelson
Senior Maintenance Worker – Trails Crew
County of Santa Clara
Department of Parks and Recreation

Don Rocha
Natural Resource Program Supervisor
County of Santa Clara
Department of Parks and Recreation

Santa Clara County Parks

Trails Maintenance Manual

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1. INTRODUCTION

1.1 Trail Maintenance Manual Objectives

This Trail Maintenance Manual was developed as a field guideline and procedure manual for Park staff responsible for the maintenance, construction, and operation of the Santa Clara County Parks trails' system. The topography, geology, climate, soils, and vegetation vary throughout the trail system of Santa Clara County Parks; therefore this manual may not be applied throughout the system. This manual is not intended to, nor capable of, supplanting trained, experienced and skilled park staff. It is intended to provide guidelines for Park staff charged with trail maintenance and construction responsibilities, and provide base knowledge of trail management and construction practices for the inexperienced trail worker. The guidelines within this manual address all types of trails including single-track, dual purpose, multi-use, paved trails, and service and fire roads. This manual complies with the Santa Clara County Parks, Countywide Trails Master Plan and uniform Inter-jurisdictional Trail Design, Use and Management Guidelines-1999.

The goals and objectives of this trail maintenance manual is to provide standards and guidelines for trail design, maintenance, construction and management so trails are sustainable over the long-term, require low maintenance, allow for safe public access, protect the natural and cultural resources and meet recreational needs of the park user. A common mistake made by many park professionals is becoming so focused on the construction and maintenance of trails that they often overlook the role trails play in overall park operations. Sections of this manual are dedicated to trail standards, maintenance priorities and activities, trail construction standards, and trail feature construction and maintenance to address not only the respective guidelines, but also address the role of trails in parks.

Trails are park facilities similar to restrooms, campsites, parking lots, and roads. They are developed to provide access to the natural, cultural and scenic resources of a park and to enhance the visitor's enjoyment of those resources.

The ***resource values of a park always take precedence over facilities***. *All decisions regarding design, layout, and construction of trails should be based on what is best for the park's resources.* If a compromise is to be made, it should be with the trail's design not with the park's resources. Sensitive natural or cultural resources should never be jeopardized by a trail facility.

This manual identifies a variety of structures and techniques that can be employed to design trails around sensitive areas or minimize resource impacts. ***If a trail cannot be constructed without significantly impacting resources it should not be built***. Furthermore, if a trail becomes too costly to construct or maintain because of additional structures required to bypass sensitive resources, it should not be built.

Remember, as employees of the Santa Clara County Parks, we are charged with the stewardship of the Park's valued resources.

Aesthetics are a primary reason why visitors come to natural settings and hike trails. The sights, smells, sound, and textures, which stimulate the mind, senses, and spirit of the visitor, are all related to aesthetics.

Aesthetic considerations in trail maintenance and construction should always be a primary concern. A well-maintained and constructed trail will provide the visitor with a pleasant and memorable park experience.

Aesthetic guidelines are difficult to formulate. By following the guidelines set forth in this manual, trail construction and maintenance can be done in an aesthetic manner. For example, trail structures and features should match, or blend, with the natural surrounding environment. This is accomplished through the use of native materials or non-native materials that match the natural environment.

1.2 Roles and responsibilities

Park Unit Maintenance staff has responsibility for trail maintenance activities. These activities are under the direction of the Park Maintenance Supervisor for that Region with field lead direction by the Senior Park Maintenance Worker. Park Ranger staff have secondary responsibility for trail maintenance, however Park Ranger primary responsibility includes park protection and therefore play a major role in trail management, maintenance and construction. Park Unit personnel should work with, or consult with, Santa Clara County Park Trail Crew for trail maintenance and management information, when necessary, or when applications are outside of the experience-level of Park Unit Maintenance staff or information provided within this Trail Maintenance Manual.

All new trail construction and facility maintenance activities (i.e., trail structure reconstructions, trail reconstruction, etc.) shall be under the direction of the Natural Resource Program Supervisor (with new construction approvals from Management staff and permitting), with field lead direction by Senior Park Maintenance Worker-Trail Crew, or Project Crew Chief (trail structures). These crews may operate solely provided they are working on approved (Department, Maintenance Division and Natural Resource Program) and authorized (CEQA, Permits, etc.) trail projects (new trail construction, trail re-route, structure replacement, new construction of structures, trail reconstructions, and trail obliteration and restorations).

1.3 **Trail Maintenance Activity**

Trail maintenance is the process of keeping a trail at or near its original construction or intended standards. The responsibility of maintenance of trails within Park Units is with the Park Maintenance Supervisor, Senior Park Maintenance Worker and Park Maintenance Worker.

There are five major objectives in maintaining Santa Clara County Park trails (in priority order):

1. Visitor and Employee Safety
2. Resource Protection (natural and cultural)
3. Public Access
4. Long-term Maintenance-ability of the trail
5. Visitor Convenience

Trail maintenance consists of the following activities:

1. Drainage structures must be built and maintained to prevent loss of soil through erosion.
2. Trail structures such as bridges, foot logs, puncheons, rock culverts, etc. should be kept safe for travel.
3. The trail must be cleared of debris and obstructions to allow for safe access.
4. The tread surface must be maintained to provide an adequate walking or riding surface, free from obstacles or hazards.
5. Brush must be cut to define and protect the established tread.

1.4 **Trail Maintenance Priorities**

Trail and/or Fire road maintenance should address the trail/road surface, cut banks, and fill slopes, as well as drainage structures and erosion control measures. A poorly maintained fire road and/or trail surface will channel water, reduce fire road and/or trail life and increase erosion and sediment pollution to streams. **The first rule of maintaining a stable fire road and/or trail surface is to minimize use during wet conditions. Fire road and/or trail surfaces should be graded only when needed to maintain a stable fire road and/or trail surface and to retain the original surface drainage.** Grading should only occur when surfaces are slightly damp. Fire road and/or trail surfaces graded when they are too dry will not compact and will result in subsequent erosion.

Before attempting to establish priorities, trail work must be broken down into essential and nonessential activities. *Essential activities* are those, which provide for visitor and employee safety, natural and cultural resource protection, and trail investment. *Nonessential activities* are those, which are directed solely toward visitor or employee convenience.

Trail work directed mainly toward visitor convenience could sacrifice visitor safety and resource protection through the neglect of essential maintenance activities. Neglect of

drainage maintenance can develop into situations where a trail system could literally be washed away

An annual maintenance program will prevent expensive reconstruction projects. With the understanding that there is a limited amount of money and manpower for trail work, that work should be directed toward factors that are causing the most damage. Ideally, drainage maintenance, clearing, tread maintenance and brushing are considered annual routine trail maintenance and performed as a unit by Park Unit Maintenance, Park Ranger, volunteers and in a limited fashion the Trail Crew. Construction, reconstruction, rehabilitation and restoration are considered facility trail maintenance and performed on a project basis primarily by the Trail and Project Crews with assistance from the Park Unit staffs and volunteers.

The following chart list the essential trail maintenance activities by their priorities, maintenance occurrence.

Annual Trail Maintenance	Priority	Maintenance Occurrence
Emergency Drainage	1	Major water flow/runoff
Minor Structure Repair	2	Annual
Drainage Repair	3	Annual
Clearing	4	Annual
Minor Tread Repair	5	Annual
Brushing	6	Annual

Annual Trail Maintenance tasks should have minimal supervision and could be conducted by ***trained*** Park Maintenance staff, volunteer crews, Conservation Corps, and inmate crews.

1.5 Trail Classification Matrix

To effectively manage trails, it is imperative to designate each trail into a general category or class. The placement of trails into these classes is determined by utilizing specific criterion with predetermined values. Using these criteria and their respective point values, each trail can be valued objectively as well as comparatively. Once each trail is evaluated, it is grouped into a class based on the total number of points it receives. For example, 20 points or greater constitutes a Class 1 trail, 10-19 points constitutes a Class 2 Trail, etc. **(See Trail Classification Matrix Figure)**

Placing trails into class categories allows Park Managers, Park Supervisors, and those responsible for trail maintenance to objectively assign standards and work priorities to trails which are consistent with their primary function, environmental sensitivity, relationship to developed facilities and visitor use. Class 1 trails are assigned the highest trail construction and maintenance priorities. The standards for Class 2, 3 and 4 trails diminish respectively to their classification with Class 4 trails receiving the lowest.

The process of classifying trails should be performed at least once every 5 years. Facility developments, natural and cultural resource concerns, and visitor use patterns are subject to change and a trails point value may rise or decline accordingly. Periodic re-evaluation of trail point totals and classifications will insure the current systems' needs.

2.0 Trail Standards

The following are general trail maintenance standards that apply to all trail types, in order to maintain a trail in its current condition for public safety, resource protection and accessibility:

1. Free of trash and debris, hazardous roots and limbs.
2. Surfaces and drainage structures are free of sloughing and erosion with proper drainage.
3. Trails should be maintained to get water off the trail as quickly as possible. Culverts and other drainage structures are free of debris and free flowing (all drainage structure outlets should be “armored” or rocked to dissipate energy of accumulated water flow).
4. Vertical clearance of 7’ for hikers, 12’ for equestrian use.
5. Side clearance of vegetation of 2’ (3’ for Poison Oak).

A minimum of 1% - 3% and a maximum 5% out-slope should be maintained where possible to allow water to sheet flow naturally off the trail tread surface. Depending on grade of trail, outflow alone may not be feasible, therefore drainage structures may need to be installed and maintained to minimize erosion and soil loss.

2.1 Brushing

- Clearing Width: The minimum horizontal clearing width from physical obstructions varies based on the type of trail but shall be no less than 2 feet from the outer limits of the trail tread.
- Shrubs and grasses should be cleared 2' from edge of trail tread.
- Paved trail shoulder should have an aggregate material compacted 2' off trail tread.
- Trail brushing should be performed annually beginning in the late spring to allow access to entire trail. This work should be performed during the months of May and June, except where sensitive species or habitats indicate otherwise.

2.2 Pruning

- Vegetation growth should be cleared and obstacles should be removed where necessary on an as needed basis. Good pruning practices along trails should be followed (see appendix).
- Vertical clearance distance from overhanging branches should be pruned to 12' for optimum clearance on Shared-use, Limited-use, and Single-use trails for equestrians and bicycles.
- Vertical clearance for single use hiking trails shall be no less than 7'.
- Any fallen limbs or debris, which prevents access, should be removed as soon as possible.
- All cut limbs and other cuttings should be removed from the trail edge and discarded in such a way as to not be a visual distraction, away from drainages, and not create a fuel ladder for a wildland fire.
- 2' minimum vegetation clearance on each side of trail. Prune all brush over 12" in height and 1/2" in diameter that extends into the trail.

2.3 Trail Tread Standards

The standards for trail tread will vary with type of trail and side slope angle. For logical reasons the cut slope (uphill) and fill slope (downhill) will also be considered here.

Type of Trail

The width of the tread will vary from 4-feet to 12-feet depending on the type of use. There are five basic trail use types: 1) Single Use; 2) Pedestrian/Equestrian, 3) Multi-Use (non-fire road), 4) Paved Shared Use, and 5) Multi-Use & Fire Road (standards also apply for roads that function solely as fire or service roads and allow for no public access). The variation in tread width dimensions allows the trail to flow around natural barriers and provide for safety and resource protection.

1) Single Use trails (hiking)

Hiking only trails are incorporated in areas of unstable soils, unique resources and other areas unsuitable for high impact use. These trails will have minimal line-of sight distances often less than ten feet. Minimum tread width varies from 3 feet for shallow side slopes (less than 30%) up to 4 feet for steep side slopes (greater than 30%).

2) Shared Use trails (Pedestrian/Equestrian)

Pedestrian/Equestrian trails occur in stable soils with minimum line-of-sight distances of 50 feet. In areas with adequate line-of-sight but unstable soils, retaining walls are necessary for tread stability. Minimum tread widths will vary from 4 feet for shallow side-slopes (less than 30%) and up to 6 feet for steep side-slopes (greater than 30%); with the intent to achieve full bench cuts where possible.

3) Shared Use trails (Multi-Use)

Multiple use trails occur in stable soils with minimum line-of-sight distances of 75 feet. In areas with adequate line-of-sight but unstable soils retaining walls are necessary for tread stability. Minimum tread widths are 6 feet for shallow side-slopes (less than 30%) and up to 12 feet for steep side-slopes (greater than 30%); with the intent to achieve full bench cuts where feasible.

4) Paved Shared Use trails

- Paved trails should be inspected weekly to keep them free of loose gravel, debris, broken glass and other litter.
- Trails should be swept/cleaned monthly and more frequently during fall months to remove leaf litter.
- Damaged pavement should be replaced as soon as possible.

- All culverts should be inspected during fall months to remove debris that could lead to possible blockages.
- Trail shoulder shall have 2'-0" compacted 1/2" aggregate.
- All overhanging limbs shall be pruned to 12' minimum.
- Pruning will be done during such times as not to interrupt nesting season.
- Line of sight considerations of an optimum distance of 100' where possible.

5) **Multi-Use & Fire Road**

Regular road maintenance is essential to protect the road and to prevent environmental damage. All roads used for vehicle travel should be regularly inspected and maintained. When maintaining fire roads and/or multi-use trails heavy equipment is primarily used. As such, grading should cut deeply into the fire road and/or multi-use trail surface so loose material will mix, compact and bind with underlying materials. If deep ruts and potholes cannot be graded out, the surface should be ripped and then graded and re-compacted (using 6" lifts) to achieve proper binding. Berms that concentrate runoff during winter rains should not be left the outside edge of the road.

2.4 Inspection and maintenance schedules

Fire road and/or trail and drainage structures should be inspected bi-annually, at a minimum, prior to the beginning of the rainy season and following initial rains of the winter. Inspections should cover culvert inlets and outlets, ditch relief culverts, and fire road and/or trail surface drainage such as waterbars, rolling dips, beneath bridges for flow, outsloping, and ditches.

In addition to bi-annual, pre-winter and initial rainy season fire road and/or trail and drainage structure inspections, crews are needed to inspect and perform emergency maintenance during peak winter storms. Shovel work at a culvert that is beginning to plug can save the expenditure of thousands of dollars to rebuild an entire stream crossing after it has washed out, and minimize stream impacts due to sedimentation into a creek system.

Some drainage structures are more prone to problems than others. For example, culverts on streams with heavy sediment loads or floating woody debris may be more likely to plug. Land managers frequently know which culverts in their trail system have had the most problems, and which are most likely to plug during a winter storm. This information can be used to develop a rating system and inspection plan for drainage structures in a watershed. Signs along the fire road and/or trail or mapping can code culverts. These information gathered should note: 1) where the culvert is located (trail name and milepost), 2) diameter of the culvert, and 3) a number or color coding that signifies how likely the culvert is to plug, and, therefore, its relative need for inspection during winter storms.

Facility Maintenance	Priority	Replacement
Structure construction/re-construction	1	
Bridges		15-20 years
Puncheon		10-15 years

Steps Retaining Walls		10% of total yearly As needed
Drainage facility construction/reconstruction	2	As needed
Trio rehabilitation	3	Performed every 5 years
Turnpike construction/reconstruction	4	Every 10 years
Trail Reroute	5	As needed

These cyclic replacement occurrences are contingent on normal wear-out life spans. Storm damage, vandalism and other uncontrollable acts could greatly increase replacement times. Periodic trail inspections would keep trail management decision makers abreast of current conditions (typically, performed by trained Park Trail Crew and Project Crews).

Trail Class determination should determine when the periodic inspections should take place. For instance, high use trails would need more frequent inspections versus low use trails in stable environments. Until the time that the trail classes are determined, trails will be assessed and classified by the Parks Trail Crew and Trails Planner. Following initial assessment, periodic inspection timelines will be determined and indicated to each Park Unit Maintenance Lead for implementation by trained Park personnel.

2.5 **Trail Rehabilitation**

When the workload required to keeping a trail system safe for visitors and free of resource problems begins to exceed its normal maintenance requirements, a rehabilitation program should be pursued. This situation usually occurs when trail maintenance programs are not diligently followed or inadequately funded or staffed. Unforeseen natural disaster such as floods, storms and earthquakes can adversely impact a trail system as well.

The process of identifying and quantifying the work to be under taken in a rehabilitation program is similar to a maintenance operation. Each trail is inventoried and inspected but instead of listing all trail structure/features, only those items requiring repairs are identified measured and logged (see Appendix-Trail Log). Facility (project) trail maintenance will be prioritized and submitted for funding during each fiscal year budget development process. The Senior Park Maintenance Worker-Trail Crew, Parks Trail Planner and the Parks Natural Resource Program Supervisor will submit a 5-year trail plan to be implemented in conjunction with Park Unit staff, Trail Crew and Project Crew to the Parks Maintenance Division Manager and Supervisory staff for approval. The 5-year trail plan will be integrated in to the Park Unit's Unit Plan for the Maintenance Division and reviewed annually during the budget development process for implementation and assessment.

2.6 **Low Maintenance Roads and Trails**

Due to the increased amount of impact to the Park system's Natural Areas by fire roads and 10-12-foot multi-use trails. Where appropriate, the Santa Clara County Parks Department will be following the standards and guidelines of the *Handbook for Forest and Ranch Roads*, Mendocino County NRCD. It is also the intent of Santa Clara County Parks to comply with all local, state and federal regulations pertaining to fish barriers, improved fish access and minimized habitat and species impacts.

Since the department has numerous fire road and 10-foot wide Multi-Use trails out of standard, there are cases whereby the department must maintain trails that do not meet the trails standard. As such, insloped fire road and/or multi-use trail with ditches should be constructed only where road surface drainage discharged over the fill-slope would cause unacceptable erosion or discharge directly into stream channels, where fill-slopes are unstable, or where out-sloping would create unsafe conditions for use. It is generally preferable to out-slope road surfaces in order to disperse road surface runoff before it has a chance to concentrate. In many instances, Santa Clara County Parks will be rehabilitating existing fire roads and/or multi-use trails, and in some instances they will be constructing new fire roads and/or multi-use trails. In order to maintain a stable road surface on native material roadbeds, or multi-use trail treads when rehabilitating, grading should cut deeply into the fire road and/or multi-use trail surface so loose material will mix, compact and bind with underlying materials. If deep ruts and potholes cannot be graded out, the surface should be ripped and then graded and re-compacted to achieve proper binding. Berms that concentrate runoff during winter rains should not be left the outside edge of the road.

The features described in this section form the building blocks of stable fire road and/or multi-use trail construction and maintenance (natural surfaced trails 10-12-feet in width). They include elements of the road's physical environment, critical control points and how to keep a stable road once it's built:

A. Physical environment

The physical environment of the fire road and/or multi-use trail includes such factors as the slope of the land, the types of bedrock and soils through which the road passes, as well as surface and subsurface drainage across the alignment. As mentioned previously, this is also try for dual and single purpose trails. The following are guidelines for constructing fire roads and/or multi-use trails:

B. Control Points

The stability of a fire road and/or multi-use trail and its impact on the environment are often determined by how the road is designed and located around physical points of control in the landscape. When planning and locating a fire road and/or multi-use trail alignment efforts should be made to avoid as many obstacles and stream crossings as possible.

C. Keeping a stable fire road and/or multi-use trail.

A fire road and/or multi-use trail built with drainage structures and stream crossings needs to be maintained and monitored during the winter period (as storms occur), during the summer period (as it is being used), and preceding winter period (to prepare the road for winter). Periodic and storm maintenance inspections and activities need to be performed frequently and regularly during the first several rainy seasons as the road "settles in" and stabilizes. Each year that follows, the road and its drainage structures should be regularly checked and, when necessary, repaired.

D. Drainage on fire road and/or multi-use trails

The key to successful surface drainage is to get the water off the cut-slopes, fill-slopes and road surface as quickly as is possible, before it has an opportunity to concentrate into a flow, thereby cutting into the soil and transporting sediment into nearby streams. The two most important rules for accommodating surface runoff are 1) get water off the road *rapidly* so it cannot erode (through high velocity water movements) or seep into the roadbed, and 2) get it off the road *often* to avoid large, erosive flows from developing in long, drain ditches where velocity of water flow erodes the soil.

In order for stream crossing culverts to function properly, culverts should be installed at a stable grade (preferably at or slightly below the bed of the original stream channel). It is best for the road to cross at right angles to the stream channel, but regardless of the road alignment, the culvert should be placed parallel to, and at the width of, the natural channel so that the inlet will not plug and flow from the outlet will not erode either of the channel banks.

On fish-bearing streams, fish passage must be designed into all watercourse crossings. Most obstructions can be prevented if the potential for fish passage is recognized during road planning. Culverts should be placed at or slightly below grade. If flows are rapid, the culvert diameter should be increased and the culvert grade reduced. Resting pools should be designed immediately below and above the culvert. Maintaining a stable stream bottom through the culvert-influenced area is essential. Avoid installation of round culverts where fish passage might be difficult. Instead, use either open arch culverts or bridges (per California Department of Fish and Game and/or National Marine Fisheries design guidelines).

3.0 Clearing

3.1 Definition

Clearing Maintenance is the removal of windfall trees, uproots, leaning trees, loose limbs, wood chunks, and slides from the trail travel way.

The clearing dimension is determined by the trail type and classification (as specified in the standards).

3.2 Large Down Trees

Down trees over 3-feet in diameter across trail should be given special consideration (possibly reroute trail around tree) and the decision on the trail reroute must be approved by the Parks Natural Resource Supervisor.

Limbs, branches, and wood chucks on the trail, including those on the side hill above the trail that could fall on the trail tread, should be thrown clear, and in most cases stashed to not distract from the trail corridor, beyond the margins of the trail travel way. Cut log rounds should be rolled off the downhill side of the trail, or on flat ground, far enough off the travel way that it cannot be seen. Cut ends and root wads left on the side hill should be blocked or anchored so that they will not fall into the trail.

All loose rock or soil in the disturbed area shall be removed and the trail tread restored to as close to its original condition as possible.

In heavily wooded areas there is a certain amount of timber and debris that fails each year and lies across the route of existing trails. Unless maintenance crews are quick to remove the debris that obstruct the trail, users will create detours above or below the gradient of the trail in order to get around the obstruction. The end result is unwanted way trails that create resource damage and an additional maintenance workload.

Cut back all logs, centering the trail and maintaining the standard clearance for the trail type. All other limbs that are not obstructions shall be left in their natural state. Regardless of a tree's location, cut all limbs that are obstructions flush with the trunks of the trees. NOTE: No projecting stumps shall be left. All brush, limbs and roots that are cut will be removed to the high side, out of sight of the trail.

Crews walking to and from the work site will remove all fallen limbs, loose chunks, logs and roots from the immediate upper slope (for 6-feet back), from drainage ditch, tread and shoulder of the trails. Scatter this debris out of sight on the high side of the trail. Do not blaze, carve or otherwise mark or deface trees, limbs or other natural features. Snags, leaning or other dangerous trees shall be identified to the Senior Park Maintenance Worker and documented. Do not fall any tree without prior approval from Park Maintenance Supervisor or Natural Resource Program Supervisor.

4.0 Brushing

4.1 Definition

Brushing maintenance consists of the removal of all living or dead vegetation from the trail travel way, as needed for resource protection, safe trail access or protection of the trail.

4.2 Natural and Cultural Resource and Trail Protection

When brush grows or is forced in the trail corridor, trail damage often occurs when trail users are forced off the established trail tread and onto the berm (bank of fill slope). This brush is usually of the woody type and is fairly slow growing.

Native flowering woody plants shall be pruned instead of brushed whenever possible.

Brush removal is very simple. The key is “find the source”. Often many of the branches in the trail grow from a singletree or main branch. These are easily located and cut off flush at the base of the tree or main branch. This **cutting at the source** can save many years of brushing individual branches. Other less woody species can be cut back to standard widths and maintained at that level every year (See Appendix-pruning diagram).

Limbs cut from standing trees should be cut flush at the trunk, leaving no stubs and care should be taken to prevent tearing of the bark.

Debris should be scattered up and beyond the trail corridor. Cut or loose material on the uphill bank that could possible fall into the trail should be pulled off and thrown beyond the trail corridor. Little cut material should be left on the trail tread.

No debris should be disposed of in any drainage, natural or constructed.

4.3 Overlook and Vista Points

One of the most pleasing and surprising aspects while hiking a trail is to come on a vista point or overlook. Every effort should be made to maintain traditional vista points and overlooks.

Brushing of vista points should be done as thoroughly as possible, down to the ground level. Leaving a brush barrier or low screen has proven ineffective. Hikers will continually try to breach a brush screen to get the best view. Instead, brushing should be completed to ground level and a rail installed. A rail provides a definitive barrier as opposed to a brush screen.

5.0 Tread Maintenance

5.1 Definition

Tread maintenance consists of keeping the tread surface serviceable.

Tread maintenance consists of:

1. Restoration of uniform outslope, inslope, or crown surfaces.
2. Restoration of original width (See trail width specifications).
3. Maintenance of back slope (angle of repose).
4. Filling of ruts and holes in trail tread.
5. Restoration of sections damaged by slides, uproots, and washouts.
6. Removal of loose rocks.
7. Restore fill approaches to puncheons and bridges.
8. Restore crown to turnpike with fine gravel or mineral soil.

5.2 Slough and Berm

Readily visible trail tread width according to its class and type will be maintained. Slough deposits on the tread will be removed and spread over the trail tread to produce the intended drainage surface (inslope, outslope, crowned). Backslopes will be maintained or restored to the angle of repose.

5.3 Trail Entrenchment

Deposits of soil berm on the outside edge of the trail will be removed and spread over the width of the trail tread to produce the intended drainage surface (inslope, outslope or crowned). Low spots in the trail tread capable of holding surface water will be drained and filled with mineral soil and/or rock not exceeding 2 inches in diameter.

Ruts, holes, gullies, and other damage to the trail tread occurring through trail use and normal exposure will be filled and resurfaced to the original trail condition as determined by the adjacent trail.

Fill and borrow material will be obtained according to the priorities listed in the “Native Materials” section.

5.4 Exposed Tree Roots on Trail Tread

All loose roots protruding over 3-inch above the trail tread will be cut out to at least 4-inches beyond the margins of the trail tread and to a depth of at least 4-inches below the trail tread surface and removed from the trail corridor. Holes resulting from root removal will be filled and compacted with mineral soil and/or rock not exceeding 2-inches in diameter.

Roots smaller than 3-inches in diameter that create a safety problem shall be removed during trio maintenance or construction.

No roots over 3-inches in diameter shall be cut to provide trail tread base. All exposed roots larger than 3-inches in diameter when determined to be a safety hazard or resource problem shall be covered with native or non-native materials.

Turnpike construction shall be used to hold materials in place.

5.5 Uprooted Trees and Slides on Trail Tread

Trail tread width shall be reconstructed to the original dimensions established for the classification. Construction guidelines found in section 7.2 shall be followed to insure proper trail tread surfaces. Care should be taken in layout of the reconstructed trail to avoid active slide movement areas. Appropriate alternatives routes shall be approved by the Parks Natural Resource Program Supervisor.

5.6 Gravel Surfacing

The placement of gravel as a surfacing material on and in the trail tread produces a durable, long lasting trail tread surface. Such gravel surfacing will extend over the full width of the trail tread. The finished surface will match the intended drainage to facilitate water run-off, and will be firm and uniform.

Material to be used in gravel surfacing will be crushed shale or pit-run up to 1-1/2 inches in diameter and free of organic material. If onsite borrow areas or stockpiles are used, they will be marked, designated and pre-approved by Park Maintenance Supervisor and Parks Natural Resource Program Supervisor (CEQA, permitting, etc.). Crusher sites and stockpile areas will be restored to a natural contour and condition to the greatest degree possible.

When gravel surfacing an equestrian trail, the trail tread shall be covered with a minimum of 3-inches layer in gravel. In poor soil conditions, the gravel will be under laid with geotextile woven fabric to eliminate the loss of gravel into the trail tread.

The trail tread shall be crowned when at or near 0% grade and outsloped on side hill construction. Associated gravel surfacing shall reflect these drainage standards. Where possible, the constructed trail surface will be compacted to firm surface for heavier equestrian traffic.

5.7 Turnpikes and Bridge Approaches

Restore fill approaches at each end of trail bridges and puncheon sections with mineral soil and/or gravel less than 2-inches in diameter. Approaches will be maintained such that the trail tread is level with the walking surface of the bridge or puncheon section.

Restore fill in turnpike sections to the original conditions, crowned at least 2-inches higher than the rail logs.

To maintain turnpikes, the ditches must be cleaned to assure sustained flow. Ditch banks should be sloped at a 45-degree angle (ratio 1:1) to prevent sloughing. If material from the ditch is mineral soil or fine gravel, it should be used to restore crown to the turnpike.

Often parallel ditches are used without turnpikes in areas with side hill seep. These also carry the water to a common drain point. These collection ditches must be cleaned to their full length.

5.8 Switchback Maintenance

Switchback maintenance involves the reshaping of the trail tread to the intended drainage, cleaning of the inboard ditch on the upper leg, maintenance of the landing between the upper and lower legs, and the rehabilitation of any short cuts developing between legs,

Reshaping of trail tread to the intended drainage normally involves removing the slough and berm on the lower leg to reestablish a 10% outside drainage. The upper leg may have been entrenched, thus blocking drainage into the inboard ditch. In such cases, regrade the tread surface to a 10% inslope.

Over the normal process of sloughing and sedimentation, the inboard ditch may silt in. remove any sediment and woody debris to maintain a clean channel beyond the landing. Make sure energy dissipaters are still in place to stop erosion back toward the landing.

The landing, through erosion and slough, may have lost its intended size. Reestablishing the turning radius on the landing to two times the trail tread width of the approaches. The landing should incorporate as inslope facing up trail, an outslope facing down trail and a crowned turning surface between both approach legs.

The log or rock barriers intended to deter switchback cutting may be inadequate and need modification. Necessary repairs should be made and more barriers may be added if necessary. Possible barrier design may include rock or wooden retaining structures (see section 14) or trail definition hand railing (see section 15). Unwanted way trails must be obliterated. This should be done to eliminate the invitation to visitors to use them See section 20.6).

6.0 Draining Maintenance

6.1 Definition

To control or direct the flow of water either across, under, through or around a trail.

There is no single factor with as much ability to damage the trail as the unchecked flow of water. The source of this water is from precipitation falling in the form of rain. During periods of heavy rain, a large amount of water is present at the surface. Some of the water is absorbed directly into the soil or humus layer. When the soil is saturated, the water that isn't absorbed flows along the surface as sheet flow until it collects into small channels that combine to form streams. The water that is absorbed infiltrates down and moves through permeable strata until encountering an impermeable layer, or until it joins the water table.

Problems occur when the trail interrupts any of the natural drainage process. The trail can intercept sheet flow or stream flow and become itself a stream channel. On a side hill it can cut through a bank and expose subsurface flow that results in seepage. In flat broad river valleys, for ease of construction, the trail may have been built in areas where the water table is close to the surface, or where there is poor run-off, forcing the construction of turnpikes or puncheons.

Trails in flat, low-lying, wet terrain, as well as mountain bogs with highly organic, wet soils, are frequently plagued by destruction of plants and surface soil horizons. Wet, slippery, muddy locations develop very quickly on these soils, causing puddling of water on the trail tread. Hikers, wanting to keep their feet dry, walk to the side of the trail tread and so cause a vicious circle of soil breakdown and trail widening. There are a number of techniques that can be applied to trails in this situation that will help to stabilize the damaged soils and allow trailside plant life to recover.

If an area cannot be drained or if for environmental reasons it should not be drained and if relocation is not feasible, then trail-hardening techniques should be used. These techniques offer dry passage for hikers and contain traffic on a hardened surface, thus allowing adjacent soils and plant life to re-establish.

In determining which drainage facility to use, the order of priorities may not always be possible to follow, depending on terrain features; volume of water involved and soil characteristics.

The intent of the order of priorities is to use the means, which is least disturbing to the natural environment.

1. Clearing the channel (potential CEQA and permitting issues, pre-approval required)
2. Maintain the outslope
3. Clean drain dip
4. Clean water bar
5. Clean parallel ditch
6. Clean culvert.

When there is water on the trail, the first question to ask is "what is the source?"

6.1.1 Clearing Channels

When small stream channels cross the trail, logs, sticks, silt or other debris can block or dam channels, causing overflow or widening of the streambed, often causing water to flow down the trail. Many times there are permitting issues related to clearing channels. Permits/MOU must be approved and conditions followed.

Clearing the drainage channel up and downstream of the crossing will help to consolidate and confine the flow to a smaller and more easily managed size. Some may be narrow and shallow enough to hop or wade.

Where puncheon bridges have been constructed, it's necessary to clean the channels leading up to, under, and away from the bridge to assure a sustained and unobstructed flow.

6.1.2 Outslope

Outslope is the method of grading a trail so that the outside edge of the trail is lower than the inside. This allows sheet flow to follow its natural course across the trail and down the slope. If the trail surface is durable, the backslope stable and the traffic and vegetation light, the outslope is easy to maintain. However, with heavy traffic, material sloughed off the backslope, vegetation growth on the outside edge, or clearing debris buildup, a berm develops.

Proper outslope will prevent the trail from becoming a channel for transporting the flow of water.

This berm and slough material should be removed. (If suitable mineral soil is found, spread it over the trail tread surface to maintain the outslope).

Ideally, all trail tread should be outsloped, but due to certain physical restraints, this is not always possible. Outslope can be quickest and most immediate form of drainage control.

6.1.3 Drain Dips

In a situation where the volume of surface water runoff is in excess of what a normal outslope design can accommodate, a drain dip may be required. Drain dips are an exaggerated outslope that terminates in a shallow trough that is of sufficient size to accommodate sheet-flow and prevent cutting and soil movement (see Figure).

Drain dips should be located where they will be the most effective (at the source). Features such as natural contours, side slopes, and trail grade must be studied closely to determine where the largest volume of water can be intercepted and diverted from the trail. Soil readability, vegetative cover and down slope steepness must be considered when selecting the drain point or trough outflow location. Ideally, drain dips should be located where natural swales or drainage's bisect the trail.

A drain dip begins on the uphill side with a normal outslope. The outslope is gradually increased (4%-10%) as the trail grade is cut and lowered to the trough and drain point. The terrain and volume of water encountered usually determines the length and the degree of outsloped used in the drain dip. Generally, the steeper the terrain and higher the flows require longer drain dips with more outslope.

Below the drain point, a ditch or drainage channel must be provided to allow water to escape from the trail and fill slope without creating undue erosion. This channel is sized according to the volume of water generated by the drain dip. This channel may also require armoring with native rock to reduce scouring and bank erosion.

To function properly, drainage dips need to be maintained. Sediments and debris that build up in the trough must be removed and the trail surface re-worked to restore their shape and outslope.

Soil removed form the trough can be used to fill ruts and holes in the trail tread or to restore the fill slope. The outflow ditch below the drain point must be cleared of soil and debris.

6.1.4 Water bars

A waterbar is a physical structure across the trail, which turns and directs the water to the downhill side of the trail. Waterbars are made of wood, rock or native soil, with rock the material of choice because of longevity and strength.

The angle of a waterbar across the trail depends on the gradient of the trail, the amount of water or drainage area of the waterbar and the off-trail terrain. Typically, the angle is 15 to 40 degrees from a perpendicular line across the trail. Waterbars at less than 15 degrees may dam up and require frequent maintenance and waterbars of more than 40 degrees may promote erosion and undercut the waterbar rocks, logs or soil. The ideal drainage works somewhere in between, at a point where the flow of the water off the trail keeps the waterbar clear of sand, soil and debris. This self-maintaining type of waterbar is the objective for any waterbar construction but may not always be possible.

An approximate rule of thumb to determine the angle of a waterbar across the trail is to begin with 15 degrees and add a degree for each percent of grade of the trail section. In other words, a trail of 15% grade would require a waterbar at an angle of approximately 30 degrees.

Look at the natural drainage of the area for waterbar placement. If the water crosses the trail naturally the waterbar will reinforce this pattern. If the trail has altered the natural drainage pattern of the area and the water runs down the trail, determine the natural, most direct drainage pattern and build the waterbar to emphasize that pattern. Try to observe the trail with water on it during winter or spring and the drainage requirements of the trail will be more evident.

To determine the final location of a waterbar, look for natural anchor points, especially large rocks embedded alongside the trail. These make excellent keystones for waterbars. Trees may occasionally be used when well located.

6.1.5 Culverts

When surface flow or subterranean springs are intercepted by a trail, culverts may be placed perpendicular to the trail in such a manner to redirect the water and divert it to the downhill side of the trail. All culvert outflows shall be directed into the natural watercourse of the intercepted flow. In most instances where a culvert needs to be installed, a permit must be attained through CDFG. Pre-approval of culvert installation by Park Maintenance Supervisor or Natural Resource Supervisor is required.

Excess soil removed from the trench should be used to backfill adjacent eroded areas and/or outslope or restore trail tread.

The culvert materials and design may be either wooded box culverts, corrugated steel, corrugated ABS plastic, smooth-bore ABS plastic or rock. Headwall and energy dissipater materials may be either rock, wood or a combination thereof.

6.1.6 Parallel Ditches

Construction of parallel (lateral) ditches will consist of excavating a depression parallel to the trail tread wide enough to carry the anticipated volume of water and maintaining a ditch bank slope of 1:1. Waterbars will be installed to drain the parallel ditches at approximately 25 feet intervals or as terrain dictates.

Where terrain and water flow permit, parallel ditches will be constructed along the trail tread margin and no vegetation allowed to grow between the ditch and the tread margin.

Where the gradient or soil conditions may cause erosion, the ditch will be lined with rock or check dams will be placed. The check dams will be set so the top of the dam is below the trail tread so the anticipated volume of water will not overflow onto the trail tread. Check dams should be placed no more than 25 feet apart on slopes up to 20 degrees, no more

than 15 feet apart on slopes of 20-30 degrees, and no more than 10 feet apart on slopes in excess of 30 degrees.

Excess soil removed from the construction of parallel ditches will e used to backfill eroded areas, outslope and restore trail tread.

6.1.7 Turnpikes

Turnpiking is the process of hardening the trail by raising the tread surface above the ground through boggy, wet, muddy areas. Because of its permanence, it is preferred over puncheon when material and work force are available for its construction. It consists of to curb logs or rock walls, placed parallel to the trail, filled with rock, gravel or soil, and then crowned. Water is collected and channeled by parallel ditches to culverts which carry the flow under the turnpike to escarpment ditches downslope.

6.1.8 Rock Causeways

A rock causeway is an elevated section of trail contained by rock usually through permanent or seasonally wet areas. Causeways can also be used to consolidate areas of multiple ruts into one trail and allow revegetation to take hold after the area has been rehabilitated.

A causeway is built to be as inconspicuous as possible. The causeway must be built close to the minimum height and width needed to bridge the problem area. The height of the causeway should be designed for the maximum flow event.

6.1.9 Drainage Lenses

Occasionally a trail will be bisected by an ephemeral spring or seep. These low volume flows saturate the base soils creating muddy unstable trail bed. A simple and effective solution to this problem is a rock drainage lenses.

7.0 Trail Re-Route and Construction

7.1 Definition

The rerouting or relocating and surfacing of sections of trail to avoid major damage or problem areas which have rendered routine maintenance ineffective and the construction of new trails where presently no trails exist.

Due to the complexities required to construct new trails and trail re-routes, the Department Trail Crew will carry this aspect of trail maintenance and construction. All re-routes and new construction must be per-approved by the Department (Natural Resource Program Supervisor, Manager of Park Maintenance Operations, and Park management Team), with all associated permits and regulations followed (CEQA, Storm Water, etc.).

The intensity, and consequently the expense, of construction of a satisfying and undamaged trail environment are controlled basically by 2 factors. The first is the volume of use an area receives or could withstand. As use increases there is more wear and tear on a trail and therefore the need for increased trail stabilization work is present if soils and plant life are to be maintained in a healthy condition. The second factor governing construction is the character of the land itself. Areas that are wet, located on steep slopes, characterized by poor soils or which support fragile vegetation require particularly careful-and sometimes costly-construction. There are construction techniques, which allow a certain degree of use in such areas, but associated costs of labor and materials will be high and an inevitable loss of natural qualities will result. Trails in these more sensitive areas should be avoided if possible-or at least minimized. CEQA guidelines will be followed.

7.2 Guidelines

This section pertains to any new construction and reroutes. Trail relocation objectives are to provide a facility that produces a minimum impact on the land, is visually pleasing, requires minimum maintenance and functionally provides for the intended use.

7.2.1 General Criteria

The following criteria should be used as a guideline:

1. Terrain and elevation variety should not be extreme.
2. Route is suitable for long season of use while maintaining ecological variety.
3. Located where suitable for both winter and summer activity to the degree the terrain and climatic patterns will accommodate it
4. Trail will take advantage of scenic panoramas, historical and resource management situations for interpretation purposes.
5. Trail grades should contour rather than climb up and over steep topography.
6. Main trail networks should disperse visitors away from fragile cultural or heavily used areas.

7. Avoid trail locations along heavy used roads. However, roads having few travelers may be used to avoid the soil disturbances associated with new trail construction.
8. Provide loop systems as well as access at varying distances along the trail so users can choose loops of varying lengths.

7.2.2 Specific Criteria

- **Flora and Fauna**

1. Avoid animal wallow areas.
2. Avoid wildlife breeding areas.
3. Consider avoiding areas where wildlife species concentrate.
4. Consider providing vistas, observation points or overlooks for observing wildlife in areas where they are likely to be seen from a distance.
5. Avoid threatened and endangered species habitat.

Soils

1. Locate on stable soils except where short sections can be structurally contained and/or a relocate would create more environmental damage.
2. Locate trail around extended rock outcropping areas and talus slopes.

Water

1. Careful consideration should be given to trail locations along bodies of water. Balance locating the trail to overlook streams and lakes and not follow along the water's edge. Provide water access points for users.
2. Trails located adjacent to bodies of water should avoid undercut banks and fragile riparian habitats.

Safety hazards to Consider

1. Talus slopes or rock slide areas.
2. Areas with concentrated numbers of snags.
3. Areas with erosion or bogging surface potential.
4. High wind zone areas.
5. Evaluate the hazard history of the location.

Cultural Features

1. Review cultural sites and incorporate or avoid them as appropriate.

- **River and Roadway Crossings**

1. Bridge crossings should be avoided if the location of the trail can make the structure unnecessary.
2. Provide safe crossings by means of bridges, underpasses except at low volume roads that can be safely crossed at grade. Special attention should be given to the safety problem that traffic noise can create for equestrians. (CountywideTrails MP).
3. Provide adequate visibility when roads of low traffic volume are crossed at grade.
4. Take advantage of natural or existing features to afford an easy and quick crossing without breaking the continuity of the trail.
5. Trail should enter and leave water on a descending and ascending grade to prevent water from draining down the trail.
6. Pedestrians and equestrians have different stream crossing needs. Considerations are depth, width, water velocity, and streambed structure.
7. Trail crossings at features such as roads, underpasses, bridges, and power transmission lines should be made at right angles to avoid prolonged visual contact and to minimize cost.

7.2.3 Alignment

The ideal alignment will “fit” the trail to the ground and afford the user the best views from the trail. The alignment should follow the contours of the land. Sharp, angular turns over 50 degrees and long, straight stretches should be avoided.

If a switchback is necessary, the most desirable alignment for a switchback utilizes a topographic feature as a turning point, so it does not appear to be “carved out of the hillside”. Provisions for screening and protecting the switchbacks with trees or brush should be incorporated in the design when the trail cannot be constructed around a natural topographic feature.

7.2.4 Grade

As a general rule, the trail should not be steeper than 10% (10-foot rise in a 100-linear foot run). Grades of 1-7% are ideal. No grade should be so steep that erosion is a problem. Do not locate at zero grades. As a general rule, some grade must be provided to adjust to drainage needs. Long stretches of a given grade should be avoided. The grade should undulate gently to provide natural drainage and to eliminate monotonous, level stretches and long, steep grades that are tiring to the trail user. Grades should be steepened at approaches to switchbacks.

A trail designed specifically for hikers may incorporate short sections of steps or steeper grades within the controls indicated if these will not cause undue disturbances and adequate drainage can be provided to prevent erosion.

7.2.5 Flagging and Layout

When it has been decided that new trail construction will take place, flagging and layout is the method to designate the new trail location. The layout can be either very precise using a transit and grade stakes or it can be simple using an Abney level or clinometers and flagging tied to vegetation. The method used will be determined by the intended use of the trail such as a precise asphalt paved trail for wheelchairs or a simple backcountry-hiking trail.

As mentioned in previous sections, it is very important for the layout team to follow the natural topographic contour and drainage patterns of the terrain. They must proceed with the thought of finding a route that will minimize the need for structures and costly maintenance. Upon selecting the most feasible route, it is important to remove all unnecessary flagging immediately in order to eliminate confusion when construction begins.

Some key points to flagging and layout are:

1. Flagging should be spaced close enough to insure that there is no confusion during construction.
2. It is not advisable to attempt a level course due to drainage concerns and natural obstructions.
3. Curved linear alignment should be adhered to as much as feasible.
4. Route should be selected to eliminate the need for as many structures as possible.
5. Deviation from the maximum grade may be made for short distances to avoid obstacles and construction of structures.

7.3 Re-Route or New Construction Guidelines

7.3.1 Clearing

In many cases, removal of vegetation requires permits. Removal of any natural features will only follow approved and permitted plans. For protection against erosion and the appearance of the area, leave all healthy trees over 12-inches DBH. In sparsely wooded areas or forests, do not remove any healthy trees except where they interfere with trail traffic and the trail cannot be relocated to eliminate the interference (With prior approval and necessary permits).

Cut off limbs flush with the tree trunk. Widen clearing area at stream crossings, resting places and scenic points where traffic may pass.

7.3.2 Base Construction

Construction of sidehill trails usually requires grading a bed for the trail, but if the existing surface is flat and provides a suitable trail tread, leave it undisturbed. This will reduce erosion and maintenance. On level ground, form the trail base by building up rather than cutting down. Remove all duff before making cuts or fills for the trail tread.

Start grading on the upper slope and carry it down to the finished grade. Remove any excess duff. Begin excavation along this line using mechanical means or hand tools.

Fill slope or backslope shall be constructed to the native materials' angle of repose. A trail bed inslope may be used when the trail fill consists of loose, unstable material, which may erode easily. A rock or log barrier may be used for safety on equestrian trails when the side slope is 80% or greater to keep the horse from walking on the outer edge. Trail base width should be widened to provide adequate trail tread. If rock or log barriers are used, it should be recognized that more frequent maintenance is usually required to keep the barrier intact.

7.3.3 Tread Construction

Normally, the native soil used to construct the trail base is adequate to carry foot traffic. Importing trail tread surface materials is costly and may be used for needs such as on heavy use trails, in wet areas, across rock slides, equestrian trails and accessibility trails.

When gravel surfacing is required, native gravel in the area should be used first (see section on Native Materials). If no gravel is available on site, consider importing from other sources (maintaining aesthetics)(See use of Non-Native Materials Section). The depth and width of surfacing must be determined in each case based on the quality of the native material, the class of the trail and the trail use.

Multi Use Trail Treads

Tread width shall meet standards. Whenever feasible and soil conditions warrant, the trail tread shall be covered with a minimum of 3-inches layer of gravel. In poor soil conditions, the gravel will be underlaid with a geotextile woven fabric to eliminate the loss of gravel into the trail tread.

The trail tread shall be crowned at or near 0% grade and outsloped on sidehill construction. Associated gravel surfacing shall reflect these drainage designs. Where possible, the constructed trail surface will be compacted to firm surface for heavier equestrian and multi-use traffic.

7.3.4 Fire road and/or multi-use trail construction guidelines

1. **Construct roads on hill-slopes of 10-40%.**

Low maintenance roads are most successful when located on hill-slopes of 10-40%. Roads can be located on hill-slopes of less than 10% and greater than 40%, but there is a need to recognize potential damage and bank failure problems. A road located on hill-slopes of between 10-40% allows opportunities for adequate drainage and a stable roadbed.

2. **Construct roads with gradients/grades of 2-8%.**

Low maintenance roads typically have gradients of 2-8%. Roads with gradients of 9-12% can be accommodated for short pitches if adequate drainage is installed. A road grade that is between 2% and 8% allows water to be controlled in a manner that will minimize adverse erosion and loss of road surface.

3. **Construct drainage with road out-slopes of between 1-5%.**

Low maintenance roads should have an out-slope of 1-5%. A road with adequate cross-slope sheds water quickly, avoiding erosive water concentration that can remove road surface and create ruts.

Out-sloped fire road and/or multi-use trail are likely to cause the least soil disturbance and soil movement, create less environmental impact and have lower maintenance costs than other designs. All-season roads built high on the hillside, or wherever the surface can be kept dry, can generally be out-sloped.

Conditions that might limit road out-sloping include, 1) steep road grades (which may make adequate out-sloping difficult), 2) winter use of a non-surfaced road (snow and muddy conditions on a steep, out-sloped road may be hazardous), or 3) up-slope runoff or excessive spring-flow from the cut-bank or roadbed (which makes an inside ditch necessary).

4. **Construct properly designed drainage structures.**

Roads that are in-sloped, have no side-slope, are of a steep climbing grade or are only slightly out-sloped need structures to divert accumulated water from the road surface. On climbing roads, the road surface can be drained using rolling dips, waterbars, or other drain structures. Rolling dips are smooth, angled depressions constructed in the roadbed. Dips should be constructed deep enough into the road sub-grade so that traffic and subsequent road grading will not obliterate them. Their length and depth should provide needed drainage, but not be a driving hazard nor allow water velocities to erode the roadbed. In general, broad rolling-dips are built at a 35 to 45 degree angle to the road, with a cross grade of at least 1 percent greater than the grade of the road with a 2-5% out-slope at the low point for surface sheet-flow drainage.

When grading drainage structures (i.e., rolling dips, out-sloping a trail, etc.) all grading should cut deeply into the fire road and/or multi-use trail surface so loose material will mix, compact and bind with underlying materials. If deep ruts and potholes cannot be graded out, the surface should be ripped and then graded and re-compacted to achieve proper binding. Berms that concentrate runoff during winter rains should not be left the outside edge of the road.

5. **Construct drainage structures that utilize natural features.**

Drainage structures are located in a manner that utilizes natural features in the land surface. Make sure water is moved across the road by dipping into all drainage channels, including small swales. When choices are available, select locations that are well vegetated or have rocky soils with low erosion potential. Where needed, add energy dissipaters to reduce erosion potential from concentrated water flow.

6. **Construct drainage structures using spacing guidelines.**

Enough road drainage structures need to be installed to move water off the road before the amount of water accumulated can cause channeling and ruts. Install a cross drain whenever a natural drainage feature is crossed. Utilize the table below when natural drainage features do not occur often enough to provide adequate drainage for the road. Rolling dips should be placed at intervals frequent enough to prevent road surface rilling and erosion, yet broad enough to permit uninterrupted travel.

Maximum Spacing of Drain Structures
Based on Road Gradient and Soil Type

Road Gradient %

Soil Type	2%-4%	5%-8%	9%-12%
Highly Erosive Granitic or Sandy	**500 ft.**	**350ft**	**200ft**
Intermediate Erosive Clay or Loam	**700ft**	**500ft**	**350ft**
Low Erosive Shale or Gravel	**900ft**	**700ft**	**500ft**

7. **Construct roads with minimum required width.**

Road width should be no wider than necessary to accommodate all reasonably anticipated uses and equipment. Low speed, seldom-used roads should be single lane with turnouts. Consideration should be made to eliminate all inside ditches not essential for collecting water from a spring or wet cut-bank.

7.3.5 Switchback Construction

A location that generally avoids switchbacks is preferable but some may be necessary in steep terrain. When they are needed, they should be located to use natural topography and vegetative screening and allow for a variety of views. The length of the segments between switchbacks can be varied to introduce variety. Repeated and visible switchbacks create excessive disturbances of vegetation and soil and severely scar the landscape. Screening the trail in the immediate area of the switchback to maximum allowable limits will discourage short cutting by trail users.

When switchbacks are necessary, construct the turns as flat as possible. On sideslopes of less than 30%, treat the switchback as a climbing turn. If this results in the centerline grade being steeper than is desirable, shorten the radius and design a step section.

Log or rock barriers should be installed between the lower and upper legs of the switchback. Provide 15-30 feet of barrier back from the turning point to prevent foot or horse traffic from crosscutting inside the switchback creating ruts followed by erosion (See Tread Maintenance).

Tread width on sharp switchbacks shall be at least double the trail width on landings. Where the outer trail tread margin is along a very steep slope or cliff, the trail tread may be 4-feet or wider.

A gutter-type ditch, 8-inches deep and 12-inches wide across the top, shall be constructed along the bottom of the cut back to extend from the spill point up grade for a distance of 20-feet. The trail tread paralleling the ditch shall have a 10% inslope that will drain water from the tread into the ditch. The trail tread surface, down grade from the crown line for a distance of 20-feet, shall be constructed with a 10% outslope that will drain water off the trail.

7.3.6 Drainage

Drainage control on a trail relates to two primary types of water control, surface and subsurface water.

Any provisions for the discharge of surface water must include precautionary measures that will prevent silting, erosion or gullying of areas off the trail. Rock placement at the discharge point will help dissipate the water and stop erosion.

Surface Water

Surface water is the water from rain that before the trail was built, flowed in a sheet along the natural ground surface but is now cut off and channeled into the trail. This water will flow along the trail and if allowed to accumulate above a critical combination for soil type, slope, and velocity will erode the trail tread surface.

Methods of diverting surface water are outslope, drain dips, water bars, ditches and by varying the trail grade when it is constructed. Intercepting ditches appropriately located above the trail in wet, swampy areas and led into a drainage structure located under the trail can also be used to advantage to minimize erosion on the trail.

Subsurface Water

Perhaps the most troublesome drainage problem in trail construction is subsurface water. The best solution to extensive subsurface wear on flat ground is to relocate the trail on the sidehill and bypass the trouble. If this is not practical, the next best solution is to lower the water table and permit the ground above to dry out sufficiently to support the trail load. As a last resort, puncheon construction should be used. In some cases, a drain ditch can be dug to divert the water into a stream. Culverts or French drains maybe used instead of open ditches.

Occasionally, trail construction on an apparently dry hillside will open up subsurface water in the form of springs. A small collection ditch that leads the water to a drain or waterbar across the tread will solve this drainage problem. A small amount of water is not objectionable if allowed to flow across the trail undisturbed, provided the trail base and tread will not become boggy.

7.3.7 Trail Structures

The use of trail structures should be held to a minimum. Alternatives should be considered in the trail design and layout. Extensive effort should go into avoidance of any structure construction and consideration of possible repairs to eliminate existing structures when replacement occurs.

Construction, reconstruction, and repair of trail structures shall be approved by the Manager of Park Maintenance Operation, Parks Natural Resource Program Supervisor and Park Construction Services Manager (Park Engineer). Trail structure construction should be coordinated with the Project Crew Chief.

8.0 Steps

8.1 Definition

If a trail has moderate to very steep grades, steps are needed infrequently and are usually confined to locations just above waterbars, where they help prevent clogging (rock waterbars). However, on steep ascends they are critical to soil retention and stabilization. The basic purpose of steps is to provide a stable vertical rise on the trail while permitting lower average grades between steps. This slows water and retains soil.

Steps must be located in the most appropriate place for a trail user to utilize and have evenly spaced rise and run, otherwise, trail users will avoid them. Trail users bypassing steps will soon create a new eroded route, which others will use. Steps rise will be 8-inch maximum. Place barriers alongside steps to prevent users from going around steps. Occasionally a drainage ditch, usually on the outslope of the trail, is needed to collect water and channel it down alongside the steps to a stable drainage spot where the water can be removed from the trail. The minimum length of steps is 48-inches, with landings a minimum of 13-inches and a maximum of 18-inches. Equestrian steps shall have a minimum of 48-inch landings and landings shall be established with soil stabilizer.

9.0 Puncheon Structures

9.1 Definition

A puncheon structure is a log or timber structure built close to the ground (3 feet or less) with or without hand rails (see handrails Section). It may be used to cross small drainages, wet areas or other places where turnpikes or causeways are not effective. It typically consists of mudsills, stringers and wood decking (see figure).

9.2 Puncheon Construction

Construction of the puncheon MUST MEET with approvals from the Parks Natural Resource Supervisor, Parks Construction Services Manager (Park Engineer), Senior Park Maintenance Worker-Trail Crew and Project Crew Chief. Typically, construction of the span will consist of placing two sound 10”x10” mud sills, each 6-foot long, buried to 1/3 their diameter. These sills will be spanned by 2-3 sound stringers (with stringers not exceeding 12-feet from sill to sill), decked and with soils dam spiked on each sill to prevent erosion and soil loss (plans must be pre-approved by the previously stated and specifications must meet Park Engineers specifications for structures).

The trail tread should approach the ends of the puncheon at level grade and flush with the walking surface or stepped up at 8-inch intervals. All brush and debris will be removed from the drainage on both sides of the puncheon and disposed of out of sight. Stumps will be cut as close to the ground as possible and limbs, bark and other debris will be scattered out of sight (keeping in mind fire potential, creating ladder fuels, aesthetics, wildlife movements, trail visibility and access, wildlife and vegetation impacts, etc.).

9.3 Puncheon Drainage Maintenance

Drainage maintenance consists of clearing of logs, sticks, sand, gravel and other debris from the parallel ditches and from under the puncheon and the outflow ditches. This acts to preserve the puncheon. All accumulated debris, leaves, sticks, silt or soil must be removed from the decking. These materials, if left on the bridge, will accelerate the rate of decomposition of the wood. Mudsills must be maintained and functioning properly in order to add to the life span of the puncheon. Typically, mudsills were not installed at all or were installed in properly leading to the stringers being placed directly on the soil. This results in “creeping”, “sag” or rotting of the puncheon.

10.0 Bridge Construction

10.1 Definition

A structure, including supports, erected over a depression or stream and having a deck for carrying traffic. The structure may have hand railings along the side(s) of the deck.

10.2 General Considerations

All trail bridge construction must be approved by the Construction Services Manager-also needs specification approval (Park Engineer), Manager of Park Maintenance Operation, Parks Natural Resource Program Supervisor and Project Crew Chief. Due to the nature of bridge construction and the sensitivity of the environment they are typically built, all federal, state and local permits and regulations must be attained prior to construction (including, but not limited to, CEQA, CDFG Streambed Alteration Permit, SCVWD permit). Where possible, natural stream crossings are best. These may be enhanced through the placement of rock (“keystone” rocks to support the flow, armor the crossing to prevent damage and erosion, and provide safe access). In general, the construction of most structures should be avoided if there are alternative solutions.

11.0 Retaining Structures

11.1 Definition

Retaining structures are designed to contain or stabilize soil, gravel and rocks. This material may be upslope, within or down slope of the trail bed or within a structural component; such as bridge abutments, ramps or cribbed walls.

11.2 Retaining Walls

Prior to new construction or reconstruction, the plans shall be pre-approved by the Parks Engineer, Parks Natural Resource Program Supervisor and Project Crew Chief. Retaining walls are utilized to keep materials above or below the trail tread in place. Footing foundations must be at least 8 inches below grade; instream application should be at least 18-inches below the lowest point in the stream, scour point or channel depth. All ends of the retaining walls shall be keyed into native soil which is not experiencing mass movements. Retaining walls shall meet aesthetic guidelines describe in the Trail Maintenance and Construction Manual.

12.0 Safety Railings

12.1 Definition

Safety railings are horizontal or diagonal structural members, which are attached to vertical posts for the purpose of delineating trails, protecting vegetation or fragile habitats, providing safety barriers for trail users at precipitous areas, and /or assisting trail users in negotiating trail structures such as steps.

12.2 Railing Locations

Safety rails may be used in those areas where the trail needs definition, especially where a history of volunteer trails are evident. Although most safety rails can be physically crossed, they can provide psychological barrier. In areas of sensitivity, fragile or noxious plant life (poison oak, stinging nettles, etc.) safety rails should be considered.

All designated overlook areas should have safety rails for the safety of the trail user. This will not only protect the trail user but prevent erosion problems as well. Safety rails should be used on steep terrain or where the trail is on a cliff edge.

Safety railings are also required on all bridges or puncheon sections that span a void 4-feet or more in depth. They also may be required on step sections with adjacent precipitous side slopes.

Project Crew Chief and Parks Construction Services Manager (Parks Engineer) will make final determination is a handrail is necessary, and will pre-approve designs to meet all State and Local regulations.

13.0 Mountain Bike Trails

13.1 Definition

Mountain bike trails are trails, which have been designated for use by non-motorized bicycles equipped for off-road use. Such trails usually are selected or constructed to accommodate the speed and erosive forces associated with mountain bikes.

13.2 Trail Standard

As with equestrian and foot trail users utilizing the same trail, mountain bikers will also be one of multiple users on appropriate trails. Safety considerations, sensitivity to other trail users and natural resources necessitate trail guidelines for trials open to multiple use including mountain bikes. The durability and erodibility of the native soils need to be considered with the design of any trail designated for mountain bike use.

Specifications for multiple use trails including mountain bikes more closely match trail designs for equestrian and Class 1 hiking trails. Mountain bike trails should accommodate multiple trail users or in some cases be limited to mountain bikers and restricted to other users (i.e., hikers). In general, trails need to be wider, have greater sight distance, have more passing room between users and have less slope. An alternative for single-track mountain bike trails is to provide a combination of narrow tread, curving rough surface, with minimum grade to control speed.

Tread widths of at least 60-inches allow for passing of 2 user groups on the trail tread surface. Narrower widths of trail may be appropriate, particularly if turnouts are provided, and/or types of uses restricted. The trail bed should be constructed to 8-feet to accommodate associated drainage structures. A full bench cut is required unless the fill slope will accommodate mountain bike use without trenching or sloughing. Cross slope shall support proper sheet flow drainage.

Tread surfaces shall be of consistency to withstand the impact of year-round tire traffic or seasonal closures may be used (See seasonal closure Procedures). If an aggregate mineral soil is not available, then follow guidelines to gravel equestrian surfaces. Tread surface should be even and relatively free of obstructions that would cause a mountain bike to lose control, especially when 2 oncoming user types are passing each other.

Switchbacks should be avoided and climbing turns should be designed where possible. The curve radii length should be no less than 12 feet on all turns in the trail.

Clearing and brushing shall conform to horse trail guidelines in sections 6 & 7.

Outslope and drain dips are the preferred *drainage methods* for surfaces used by mountain bikes. Water bars should be avoided. If water bars cannot be avoided, the upslope and downslope ends must be designed to fully cross the trail bed to prevent the mountain biker

form riding around the water bar. Parallel ditches, culverts, drainage lenses and turnpikes are other appropriate drainage designs.

Grade shall be a maximum of or average of 10%. Sustained pitches of 15-20% for 300 feet or less are acceptable if the tread surface will withstand the tire traffic without eroding.

14.0 Accessibility Considerations

14.1 Definition

To meet the recreational needs of all people and to provide access to Santa Clara County Park's system's natural, cultural, and recreational resources, "accessibility" trails shall be designed and constructed to standards that eliminate physical barriers and promote equal access.

14.2 Trail Slope and Grades

The slope must be considered both in the direction of travel and perpendicular to the direction of travel (cross slope) when designing an accessible trail.

Linear Slope and Grade

The maximum allowable slope/grade shall be 1:20 (5%) for all accessible trails. Every effort should be made when laying out an accessible trail to vary the slope/grade. Linear runs on accessible trails at a 5% slope shall not exceed 100 feet without being interrupted by a minimum 6'x6' level resting area. If necessary, the slope/grade may exceed 5%. Under these conditions, the maximum allowable slope/grade shall not exceed (8.33%) 1:12. However, any slope or grade in excess of 5% shall not have a linear run of more than 30 feet and shall have a 5'x5' level area at the start and finish of that run.

Cross slope and grade

The maximum allowable slope/grade for cross slope/grades shall be 1:100 (1%) on all accessible trails. When drainage patterns permit, the center of the trail shall be slightly crowned 1:200 (.05%) or less to provide better tracking for wheelchairs.

Ramps

The maximum allowable slope/grade for ramps shall not exceed 1:10 (10%) and shall not have a linear run in excess of 25 feet. All ramps shall have a minimum of 5'x5' level landing at their start and finish or at any change of direction.

14.3 Trail Width

The minimum allowable width for all accessible trails shall be less than 5 feet.

Rest/passing area

If the width is less than 6 feet, a minimum 6 feet x 6 feet level passing/resting area shall be provided every 200 feet and at all changes of direction, unless the linear slope requires more frequent level rest areas.

14.4 **Obstacles**

If the lower edge of the obstacle is more than 27 inches above the trail's surface, no obstacles such as interpretive signs, plaques, benches, lighting, etc shall overhang the edge of the trail by more than 4 inches.

Brushing

Vegetation shall be removed a minimum of 1 foot beyond the side edges of the trail and 8 feet above the trail surface.

14.5 **Trail Surfaces**

All accessible trail surfaces shall be firm, textured for good traction when wet, free of standing water and suitable for year-round access. Vertical surface differences shall not exceed ¼ inch and horizontal joints and gaps shall not exceed ½ inch. Gratings and decking shall have openings of less than ½ inch width and run perpendicular to the direction of travel.

14.6 **Trail Information**

Information specific to accessible trails should be available at information centers, camphost sites, bulletin boards and trailheads. This information should also be included in the park's brochures, trail guides, maps, etc.

15.0 Visitor Trail Facilities

15.1 Trail Signs

Trail signing is one of the most important parts of a trail system. There are 2 basic parts to a trail signage program: 1. Markers that indicate the location of the trail itself and 2. Directional signs, which indicate the user's direction on the trail and distance to other points.

Uniformed route markers are to be erected at appropriate points along the entire length of the trail, including road crossings, at intersections with other trials and where trails join and utilize fire roads. Uniform markers shall also be placed at periodic intervals to insure that the user is aware of which trail they are hiking and located in such a manner as to provide good visibility.

Regulatory, warning, information and interpretive signs should be erected along the trail where necessary to insure safety of the user or add to their experience. Where the trail crosses lands administered by other agencies, necessary signs should be erected and maintained by the controlling agency. Directional and trail marker signs shall meet department standards along the length of the trail, including those portions that cross jurisdictions.

15.2 Stiles

When developing trailhead facilities it is important to design the trailhead access points to meet both management and user needs (See Appendix-Trail Stiles).

Hiking Trails

Trails that are designated for hikers only may require barriers that prevent unauthorized use by equestrians, mountain bikes or off-road vehicles. Usually a combination of barriers and a simple step-over hiking stile will suffice. Natural barriers are preferred over manmade. However, in locations where livestock needs to be controlled or the terrain is open and lacking in natural barriers, fencing is appropriate. The step-over stile and barriers should be located where natural features such as steep banks, bluffs, trees or impenetrable brush can be taken advantage. This will help prevent unwanted users from traversing around the stile and barriers.

Hiker and equestrian trail

For trails designated for both hikers and equestrians, a step through stile is appropriate. Through the use of barriers, stiles, vegetation and natural terrain, access can be provided for the intended users and eliminated for off-road vehicles.

This stile uses the combination of posts, log-step over barriers, gates and logs and rock barriers. The post should be placed a minimum of 5-feet apart of accommodate designated uses. Finished height of logs should be 14" with 30-inch landings in between them. All logs shall be secured appropriate. All landings shall be reinforced and meet equestrian gravel surfacing section.

16.0 Site Restoration

16.1 Definition

Site restoration is all work required to correct any damage or disturbance to vegetation, soils, or water courses created by trail construction and maintenance activities or visitor use.

16.2 Trail Finishing

Whether the trail activity involves new construction or maintenance, the finished product should be free of construction scars, provide for maximum erosion control, encourage growth of native vegetation and reduce future maintenance and resource rehabilitation needs.

The ideal finished trail is the one that appears to have been there for a long time, with natural conditions prevailing along the sides with no-signs of axe marks, freshly cut stumps, raw banks or freshly cut limbs, etc. any limbs cut shall be cut flush with the tree trunk, brush should be grubbed out and disposed of out of sight of the trail and scattered, not stacked. Excess rock material should be treated like brush and limbs. Cut banks shall be dressed up and, where possible, covered with natural topsoil taken from the trail tread. This soil should be lightly compacted and covered in a thin layer of duff. New trail tread or reworked tread should also be compacted and covered with duff to prevent the pumping of subsurface soils and promote the sheeting of surface waters.

16.3 Abandoned Trail Obliteration and Restoration

In areas where the old trail is being relocated or abandoned, time should be taken to obliterate and restore the old trail to as natural a condition as possible. This will avoid confusion as to which trail to use, eliminate sources of erosion, restore it to a more natural appearance and help eliminate short cutting. Depending on the terrain, rock, brush, fallen timber, and transplanting live vegetation may be used to conceal the obliterated trail. In some extreme cases whereby the terrain is open, a fence may be required to prohibit access. In all cases, the obliterated trail shall be posted as not a trail and habitat restoration taking place.

16.4 Multiple Trail Reduction

It is not uncommon for short cutting and way trails to develop within a trail system. This is especially true in locations where switchbacks exist or where hikers can see the trail below and chooses the most expeditious route. Shortcuts and way trails must be eliminated as soon as they are discovered. If left uncorrected, these volunteer trails will encourage additional use and lead to damaged resources, soil erosion and drainage problems.

Once discovered, volunteer trails shall be blocked with local native vegetation materials such as limbs, logs, rocks and brush. These items should be placed in such a way as to

create obstacles for the volunteer trail user. If suitable native materials are not readily available or not effective, then safety railing or fencing can be installed to block off the volunteer trail.

The trail bed of the volunteer trail should also be rehabilitated, especially with historic volunteer trails with high historic usage. Entrenched trails must be filled and reshaped to the natural contours. If soils compaction has occurred, the soil must be scarified and aerated. The volunteer trail tread must be revegetated by planting native vegetation, transplanted from the vicinity, or seeded with native species found in the area.

Once the obliteration and restoration has been complete, the volunteer trail should be totally obscured, present a difficult and uncomfortable route to the potential volunteer trail user, and, if possible, block the view of the trail from a designated trail.

16.5 **Trail Narrowing**

When trails exceed width standards, they will be narrowed to appropriate standard. There are 2 ways to accomplish this, depending on the circumstances:

1. For trail cuts on a side slope, part of the sidecast can be pulled in. if plants are present, they should first be removed with their root ball intact and replanted into the remaining sideslope.
2. For non-cut and fill trails, block to the appropriate width with natural debris (i.e., down logs, limbs, brush, rocks and fill). Place the material in a scattered and irregular pattern so it does look natural. Rocks and logs should be partly buried with the weathered side up. Compacted ground should be scarified and aerated to aid natural seeding and restoration or for the replanting of local vegetation.

16.6 **Gullies and Check Dams**

In some situations, the gullies and ruts may be so severe and deep that filling them with native soils is impractical. Furthermore, sites may be encountered where local burrow of fill material is unavailable and hauling distances prohibit the option of importing materials. In these situations, check dams should be installed to halt further erosion and allow backfilling to occur through the trapping of sediments through natural processes.

Check dams can be installed by placing rocks, logs, or other long lasting materials within the channel perpendicular to the flow. The spacing of these materials should be as follows: no more than 25 feet apart on slopes up to 20 degrees, no more than 15 feet apart for slopes of 20-30 degrees and no more than 10 feet apart on slopes in excess of 30 degrees.

Once installed, check dams should be monitored to ensure they are in place and functioning properly. Additional dams may be required and should be installed as necessary. Once filled, check dams should not be emptied but left in place and allowed to become part of the slope natural contour. Revegetation of the filled channel may also be required if natural plant growth does not occur.

17.0 Safety

17.1 General Safety

Every employee working on trail maintenance must use every safety precaution to prevent accidents and to promote safety methods in his/her work. Considering the time and difficulty of transporting injured victims, exceptional safety precautions should be taken when working in remote areas.

It is expected of a trail crew working together that every person will promptly caution their fellow worker for any careless use of tools, when they are unaware of danger, or when their overconfidence or inexperience can result in an accident. Following are a few examples of precautions for trail crew employees. The Senior Park Maintenance Worker-Trail Crew, Park Maintenance Worker and Senior Park Maintenance worker and their Supervisors are all responsible to see that these and the many others you encounter are observed. Accordingly, Park Maintenance staffs working on trail projects and maintenance shall adhere to the safety guidelines outlined in the Park Maintenance Operations Manual.

17.2 Accident Response

17.2.1 Accident Reporting Procedures

All accidents, no matter how minor, must be reported to the Supervisor immediately (Supervisors Report of Injury Report). See Park Maintenance Operations Manual.

17.2.2 Crew Injuries

Due to the potential remoteness and inaccessibility of trail projects, injuries to trail crewmembers must be responded to immediately and efficiently as possible.

Minor injuries that require no immediate medical aid or hospitalization can usually be dealt with at the project work site or after the crew has returned, and shall be reported immediately to the Park Supervisor.

Trail Crews working in remote areas shall be equipped with portable hand held radios. If radio transmissions from portables are weak or ineffective, a radio-equipped vehicle shall be positioned at a location where it can be used to relay radio transmissions. Radio communication capabilities should be investigated and identified during project field investigation or bid-construction site visits. In the event that radios cannot be used due to work site topography, a minimum of two people shall be assigned to act as couriers. These individuals must be familiar with the area so they can go for helping case of an accident.

Once notified, local park staff shall assist with the treatment and/or transportation of injured crewmembers. Treatment and transportation or outside agency crewmembers shall comply with the emergency response policies of Santa Clara County and the Parks Department (see Park Maintenance Operations Manual).

17.3 Visitor Safety

17.3.1 Trail Closed During Maintenance

There are definite advantages to closing a trail during construction, reconstruction or maintenance of a trail, including providing for employee and visitor safety. However, notification of the public and Park unit staff shall be a priority, so park users and park unit staff can be accommodated (Santa Clara County Parks Trail Closure Procedure-Temporary Closure).

As outlined in the Department's Trail Closure Procedure every attempt should be made to provide notification to the public. In the case of temporary closure for trail maintenance and/or construction activities, Park Ranger staff is responsible for notification. However, it is the responsibility of the Trail Crew or Park staff implementing the trail project to provide a closure plan to the Park Unit Park Ranger staff. This should be part of the pre-site construction plan and notification to the Park Unit Park Ranger staff shall be at least 2-weeks prior to trail project work. Notification of the public shall follow Department Trail Closure Procedure including signage and notification in various outlets (phone message and Department website).

Signage of Trail Closures: all entry points onto the closed trail should be posted appropriately.

Example:
TRAIL CLOSED
FOR RESOURCE PROTECTION AND VISITOR SAFETY
DO NOT ENTER

Sign standard must meet Department Sign standards (See Park Maintenance Operation Manual-Sign standard).

Some consideration should be made to notifying the public of the anticipated reopening date. All signage shall be removed promptly and Park Unit Park Ranger staff shall be notified immediately when trail is to be re-opened. It is the responsibility of the Park Unit Park Ranger staff to notify the Department and the public to the re-opening of the trail (signage, phone message update, website update).

17.3.2 Trail Open During Maintenance

There are many advantages to keeping the trail open to the public during trail maintenance activities, when safe for the employees and the public. Every attempt should be made to notify the public of maintenance activities and trail conditions. Notification should be the same as with closing the trail.

Signing of trail condition: All entry points shall be posted appropriately.

Example:
TRAIL CONSTRUCTION
PARK CREW CURRENTLY WORKING ON TRAIL
PLEASE USE CAUTION

Sign standard must meet Department Sign standards (See Park Maintenance Operation Manual-Sign standard).

All signage shall be removed promptly and Park Unit Park Ranger staff shall be notified immediately when the trail project is completed and the trail is unencumbered by the trail crew.

Trail Crew must be constantly alert to the development of hazardous situations on the trail. Tools inadvertently left along the trail may create a hazardous condition for the public or staff. Visitors entering the work site must be announced to the crewmembers or escorted through the work site in the situation of heavy equipment being used on the trail project. If visitors are allowed to proceed on their own, they must be advised of safety precautions.

Equestrian Use

Equestrian use may require additional precautions for safe transit. Trail Crew members should be alerted to turn off noisy equipment, mechanized equipment and avoid sudden movements as the equestrians pass the work locations. The trail crew should stand on the uphill side of the trail as visible to the horse as possible while they pass.

High Risk Situations

Working conditions that can be deemed high risk (tree felling, heavy equipment operations, etc.) may necessitate a higher level of security (i.e., spotters at all approaches), temporary trail closure (following Department Temporary Trail Closure Procedure) at safe distances and other appropriate actions. This type of operation needs approval from Park Maintenance Division Supervisor (Region Park Maintenance Supervisor or Natural Resource Program Supervisor).

17.3.3 User Conflicts

Different trail users trying to occupy a trail at the same time and location may cause a conflict for the users and a safety concern for trail managers. Equestrians, bicyclists, and hikers all have desires and needs that may or may not be compatible.

Conflicts should be addressed on park-by-park and trail-by-trail bases. Other factors such as environmental impact, trail management, user behavior, and management to lessen the potential for user conflicts must address enforcement capabilities. When multiple user types are allowed on the trail at the same time, the trail will be wider, have less slope, curves and turns and have greater sight distances (see Department County-wide Trail Master Plan and Multi-Jurisdictional Guideline).

17.4 Tool Safety

The Senior Park Maintenance Worker-Trail Crew or the Senior Park Maintenance Worker should thoroughly cover safety with the trail crewmembers prior to starting work. These safety concerns should be covered during the Task Hazard Analysis for the trail project or maintenance activities. These include, but are not limited to:

1. Good grip of tools
2. Watch out for people around you
3. Make sure you have a clear area to swing (“Maintain your dime”)
4. Be alert of hazardous footing
5. Choose the right tool for the job
6. Make sure your tool is sharp
7. Carry the tool properly
8. Wear your PPE (Personal Protection Equipment)
9. Do not use power equipment until you have completed approved operation training.

17.5 Employee Training

Prior to beginning any trail construction or maintenance project, employees shall be provided training that covers the proper construction or maintenance techniques and procedures as well as the appropriate materials, tools and equipment required and their safe use. Formal trail training programs are required of Park Maintenance and Park Ranger staff. Trail Program will provide basic trails training and advanced training for specific trail feature and structure construction and maintenance.

Pre-project planning and training shall include the identification and review of all possible hazards and associated with the project (Task Hazard and Resource Hazard Analysis). These hazards shall be reviewed with employees and/or volunteers and work crews prior to the start of the project. Material safety data sheets shall be obtained for all hazardous materials used on the project and be kept in a location where employees can easily access them. Task and Resource Hazard Analysis shall be recorded and stored with the Senior Park Maintenance Worker responsible for the project.

18.0 Native or On-Site Material Use

18.1 Definition

Native or on-site materials are those construction material resources that occur naturally within the environment or landform that the trail passes through. Resources such as trees, rocks, gravel, soils, vegetation, and etc. can be used to construct trail features/structures when it has been determined that their use will not adversely affect the natural or cultural resources. This determination must be completed and authorized by the Department's Natural Resource Program or Planning Division (Cultural Resources), and accounted for in the CEQA or any attained permits, as necessary. Use of native materials may enhance the architectural appearance of a structure or feature and reduce visual impacts of those structures or features in the surrounding environment.

18.2 Soil

Soil may be obtained for use in the following priority order (with prior approval from Park Supervisor and Natural Resource Program Supervisor):

1. Slough on trail, silt runoff from drainage facilities, excavated soil from clearing or constructing facilities, soil from restoring backslopes or berms.
2. Soils from borrow pits or silt from waterways when authorized and permitted by regulatory agencies and vegetation is not damaged or disturbed (CEQA, CDFG Streambed Alteration Permit, SCVWD permit, etc.).

Source areas will be fully restored to their original condition (blended naturally to restore natural contour and allow for sheet-flow drainage, re-seeded with native seeds, etc.)

18.3 Vegetation for Restoration

Rehabilitation of a disturbed area will include the transplanting and seeding of native plant species typically found in the area. Such revegetation will be placed, as they would grow naturally. The Department's Natural Resource Program shall pre- approve plans.

Transplanted vegetation will be selected and harvested from areas abundant with desired species (upon pre-approval from Natural Resource Program, and attaining all necessary permits, as they apply). Harvested areas shall be left in a natural condition. Do not repeatedly use the same access point when gathering vegetation, as this creates way trails.

18.4 **Rock and Gravel**

When sources of rock and gravel are identified, appropriate permit processes must be initiated, following Natural Resource Program pre-approval, and obtained prior to any work being done.

Sources of rock and gravel may be obtained in amounts up to a cubic yard from the same general area, may be obtained for use in the following priority order (following approval by the Parks Natural Resource Program or Department Engineer, as determined by the Natural Resource Program or Park Supervisor):

1. Rock removed from clearing and cleaning trail tread, travel way and ditches and from restoring designated backslopes.
2. Talus slope rock (fist size or larger).
3. Streams or rivers as dictated by the California Department of Fish and Game Stream Alteration permit (obtained prior to beginning of work).
4. Scree slopes (Rock smaller than fist size). Pre-identified and approved.
5. Rocks on forest or woodland floors.

18.5 **Logs**

All standing trees or downed logs selected for stringers, retaining structures and split products must have site approval through the CEQA process and prior approval from the Natural Resource Program, Park Supervisor, Manager of Park Maintenance Services and Park Engineer.

All signs of disturbance must be restored to its natural, original condition.

19.0 Non-Native Materials

19.1 Definition

All trail construction materials that are imported to the worksite and are not identical to native onsite building materials. The use of these materials is appropriate when native materials are unavailable or detrimental to the resources or when non-native materials are more cost effective and provide a safer, more durable product. Prior to using non-native materials, their potential impacts or effects on the natural environment and the view shed should be considered and pre-approved by the appropriate Park Supervisor.

19.2 Guidelines

The use of imported materials shall be clean (free of exotic substances including seeds, free of toxic chemicals, etc.) approved by the Park Supervisor, Environmental Compliance, and Manager of Construction Services (Park Engineer). Non-native materials should be environmentally and aesthetically compatible with the surrounding resources.

20.0 Appendix

20.1 Trail Glossary

ABUTMENT: foundation at either extreme end of bridge that supports the mudsill and stringers.

BACKSLOPE: the bank along the uphill side of trail, usually sloped back at varying degree, depending on bank composition and slope stability.

BATTER: the angle in which an abutment or rock wall is constructed off center (<90 degrees). Also referred to as “lay back”.

BERM: the ridge of material formed on the outer edge of the trail which projects higher than the center of the trail tread.

BORROW: soil, gravel or rock materials taken from pre-approved locations away from the trail location.

BRUSHING: removal of living and dead vegetation for the trail.

CHECK DAMS: log, rock or wood barriers placed in deeply eroded trails or erosional channels to slow flow of water and allow accumulation of fine fill material behind it.

CLEARING: removal of windfall trees, uproots, leaning trees, limbs, rocks, wood chunks, etc. from the trail.

CLIMBING TURN: a turn which is constructed on a slope of 30% or less when measured between the exterior boundaries of the turn and changes in the direction of the trail 120-180 degrees.

COMPACTED: the degree of consolidation that is obtained by tamping with hand tools or by consolidating mineral soil and small aggregate in successive layers not more than 6 niches in depth.

DRAINAGE DIP: a reverse in the grade of the trail bed accompanied by outslope which will divert water off the trail tread.

DUFF: a layer f decaying organic plant material deposited on the surface of the ground principally comprised of leaves, needles, woody debris and humus.

ENTRENCHED TRAIL: a cupping, rutting, or trenching in the trail tread surface resulting from trampling, standing water, uncontrolled surface runoff or a combination of factors.

FILL SLOPE: area of excavated material cast on the down slope side of the trail cut.

FULL BENCH: where the total width of the trail bed is excavated into slope and the trail bed width is not made of compacted fill slope.

INSLOPE: where the trail bed is sloped downward toward the backslope of the trail.

MINERAL SOIL: soil or aggregate that is free from organic substances and contains no particles larger than 2 inches in greatest dimension.

MUD SILL: foundation on which a bridge is built to keep the soil and mud from deteriorating the stringers.

OUTSLOPE: the trail bed is sloped downward toward the embankment or daylight side of the trail.

PARALLEL DITCHING: a lateral drainage ditch constructed adjacent to the trail tread to catch surface water sheeting from the trail tread surface and diverting it away from the trail. Generally, this drainage system is utilized in low flat areas or areas where multiple entrenched trails have developed.

PUNCHEON: a log or timber built structure to cross a swampy, wet area. Usually consists of sills, stringers and decking.

RETAINING WALL OR CRIB: log or rock construction to support trail tread or retain back slope.

SIDESLOPE: the natural slope of the ground measured at right angles to the centerline of the trail.

SLOUGH: the material from the backslope or the area of the backslope that has been deposited on the trail bed and projects higher than the center of the trail tread.

SWITCHBACK: a turn which is constructed on a slope more than 30% when measured between the exterior boundaries of the trail 120-180 degrees. The landing is the turning portion of the switchback. The approaches are the 20-foot trail sections upgrade and downgrade from the landing.

TRAIL BED: the portion of trailway between hinge point of the backslope and the hinge point of the fill slope or daylight.

TRAIL HARDENING: the manual, mechanical, or chemical compaction /firming of the trail tread surface resulting in a hard, flat surface that sheets water effectively and resists the indentations that are created by trampling.

TRAILWAY: that portion of the trail within the limits of excavation and embankment.

TRAVEL WAY OR TRAIL CORRIDOR: includes trail tread surface and clearing limits.

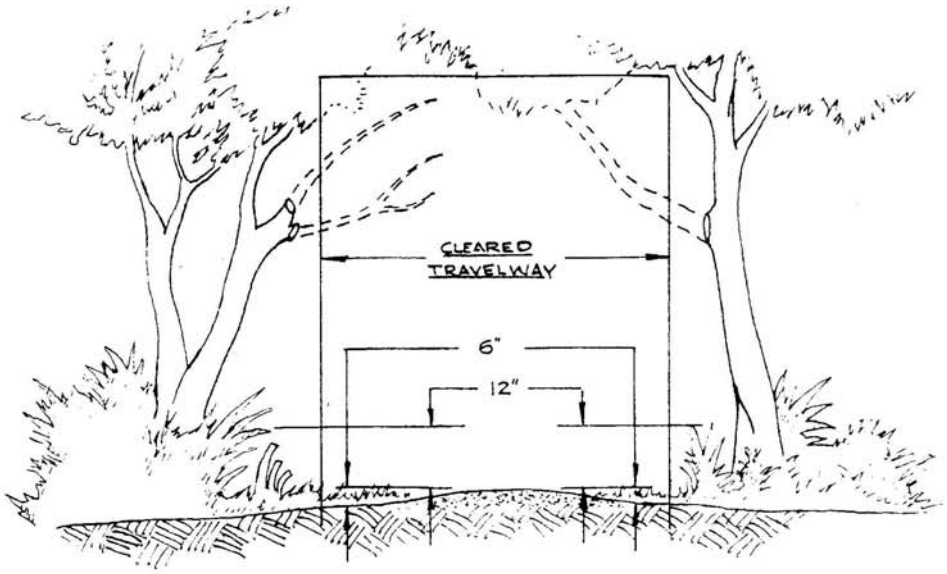
TRIO MAINTENANCE: three step function of removing slough, berm and brushing maintenance. Called fire line construction.

TURNPIKE: tread made stable by raising trail bed above wet, boggy areas by placing mineral soil between parallel side logs. Usually includes ditches alongside the trail.

WATERBAR: a device used for turning water off the trail, usually made of logs, stones or digging perpendicular trenches across the full extent of the trail.

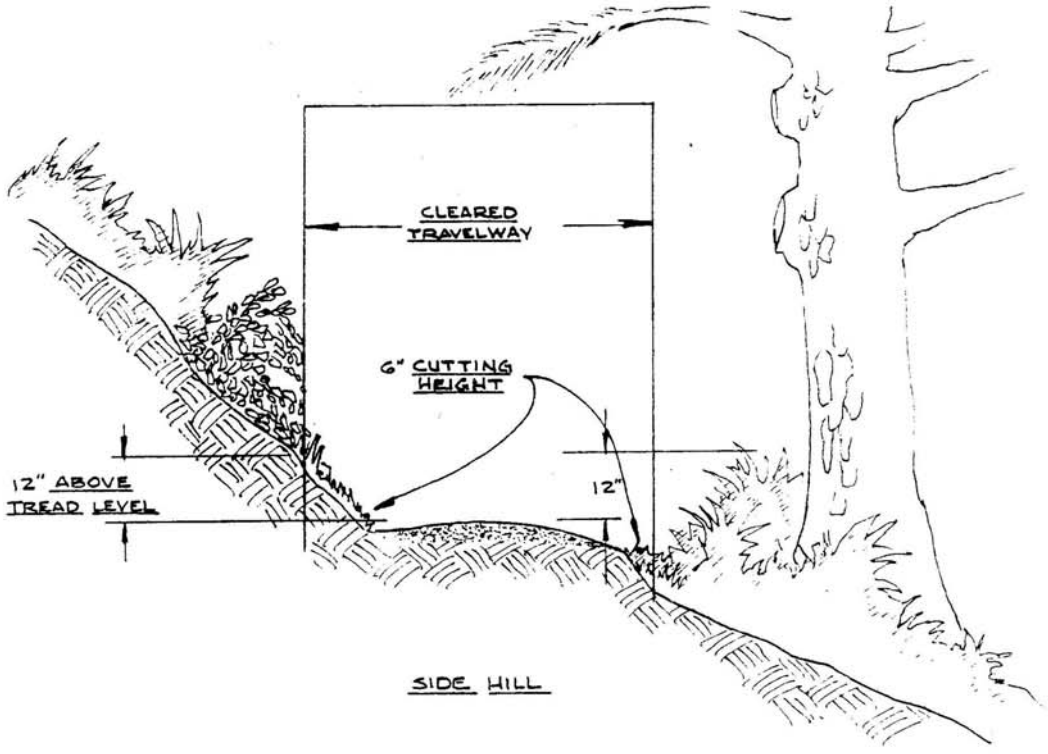
20.2 **Graphics**

BRUSHING MAINTENANCE



FLAT GROUND

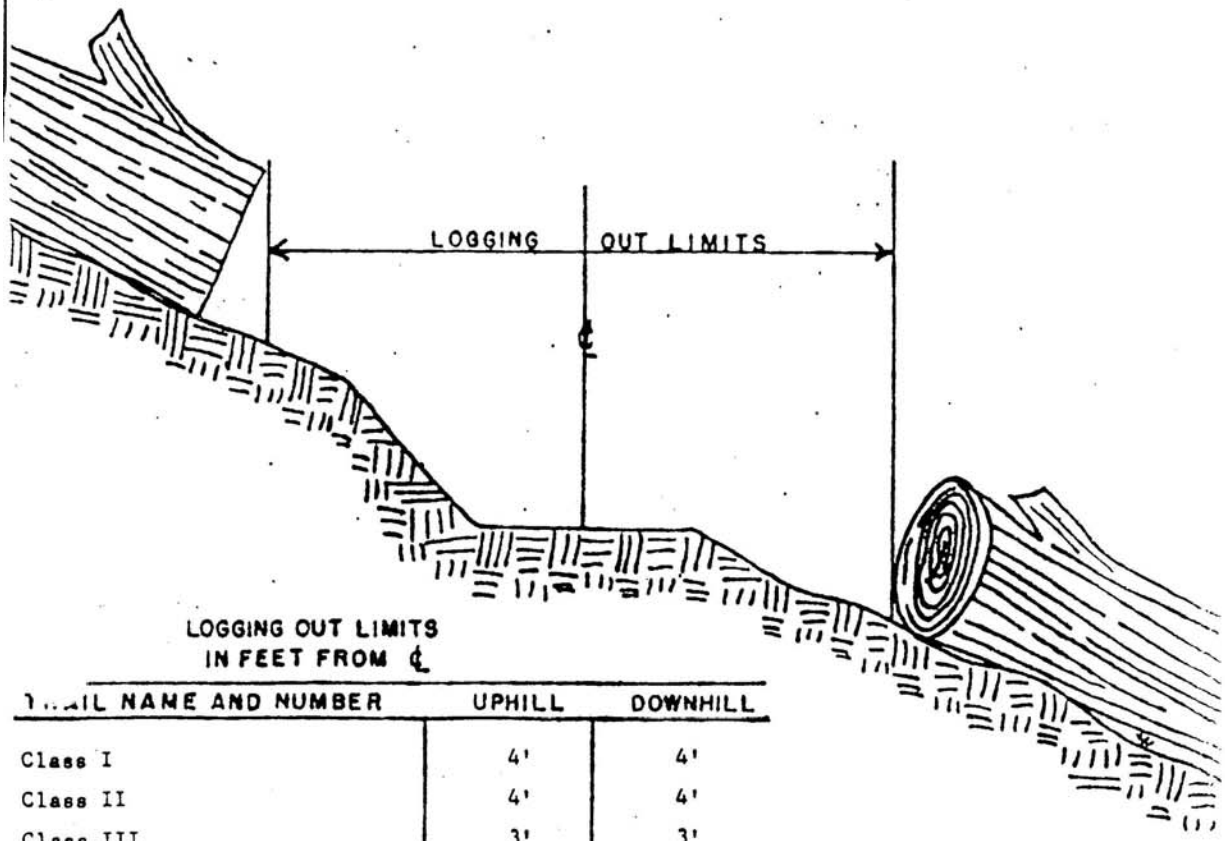
NOTE:
DIMENSIONS FOR CLEARED AREAS ARE AS FOLLOWS:
HORSE TRAILS - 8' x 10'
FOOT TRAILS - 6' x 8'



SIDE HILL

6-3

970—LOGGING OUT



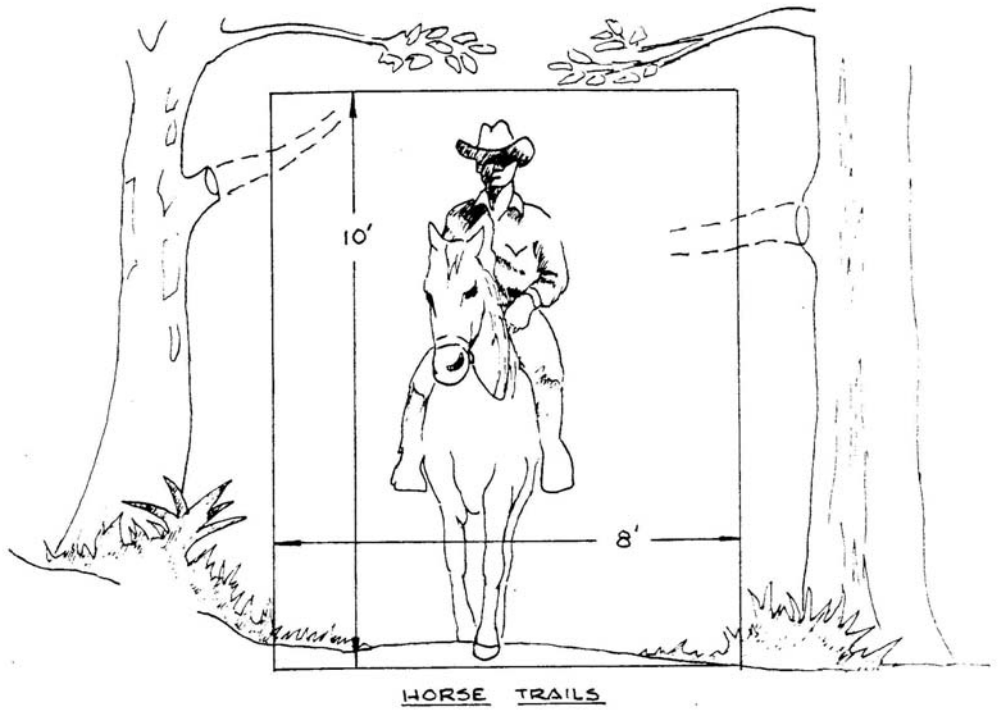
LOGGING OUT LIMITS
IN FEET FROM ℄

TRAIL NAME AND NUMBER	UPHILL	DOWNHILL
Class I	4'	4'
Class II	4'	4'
Class III	3'	3'
Class IV	Minimal For	Passage

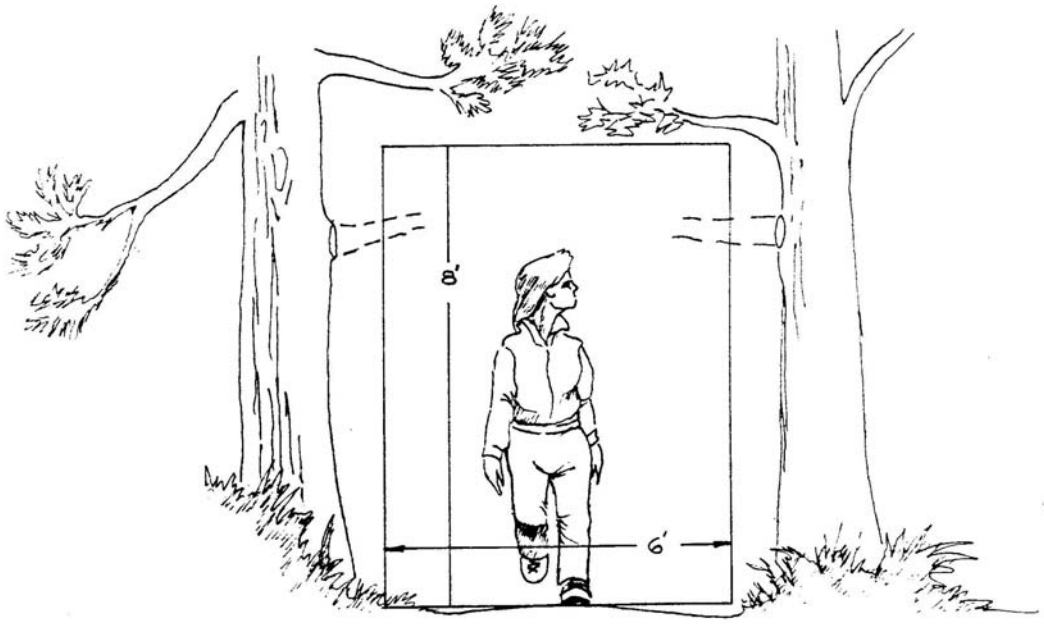
NOT TO SCALE

970—3 (3/80)

Figure 6.1



HORSE TRAILS

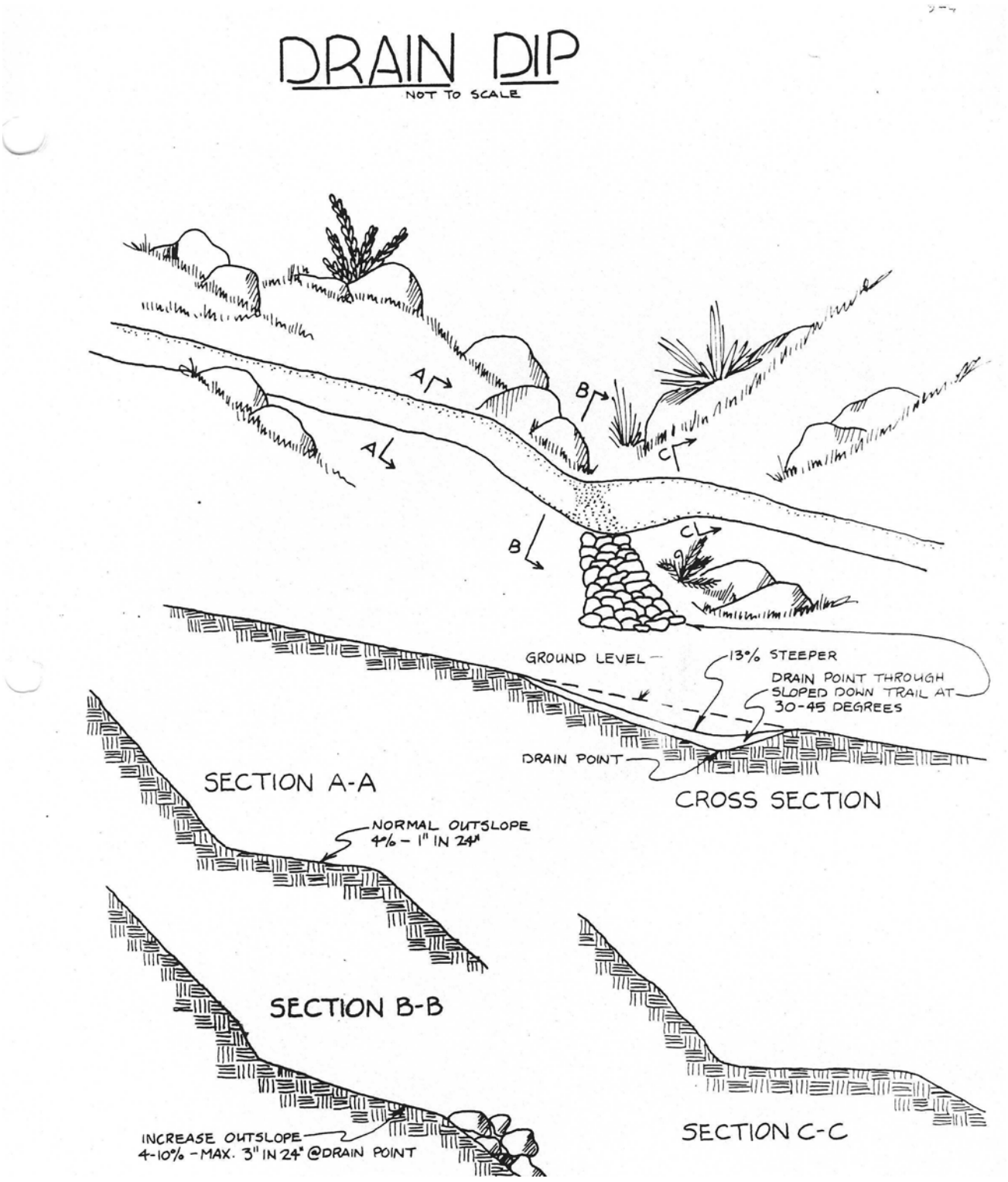


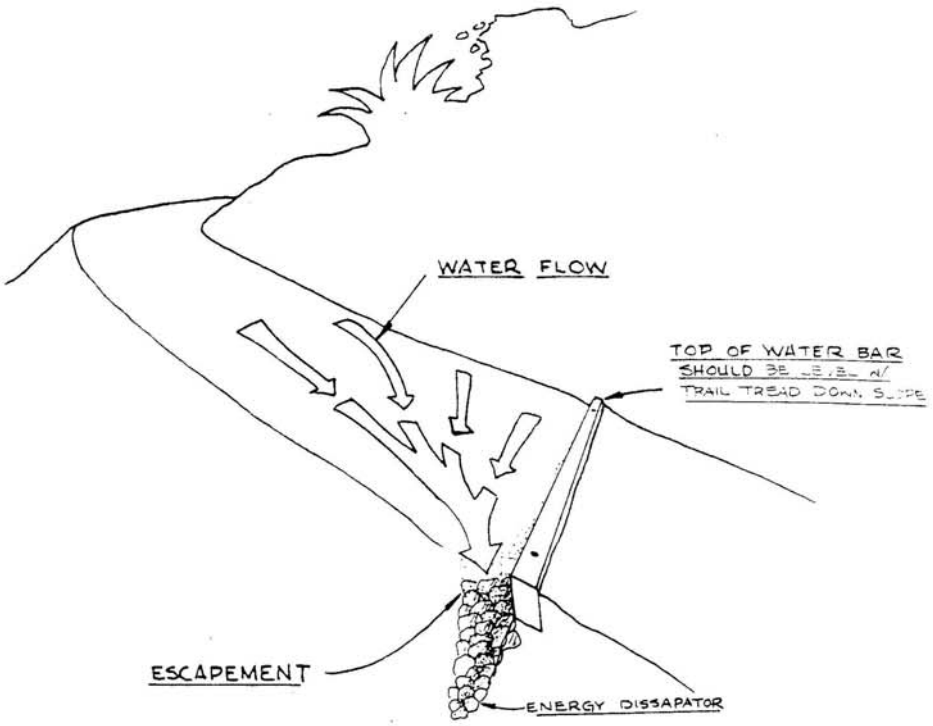
FOOT TRAILS

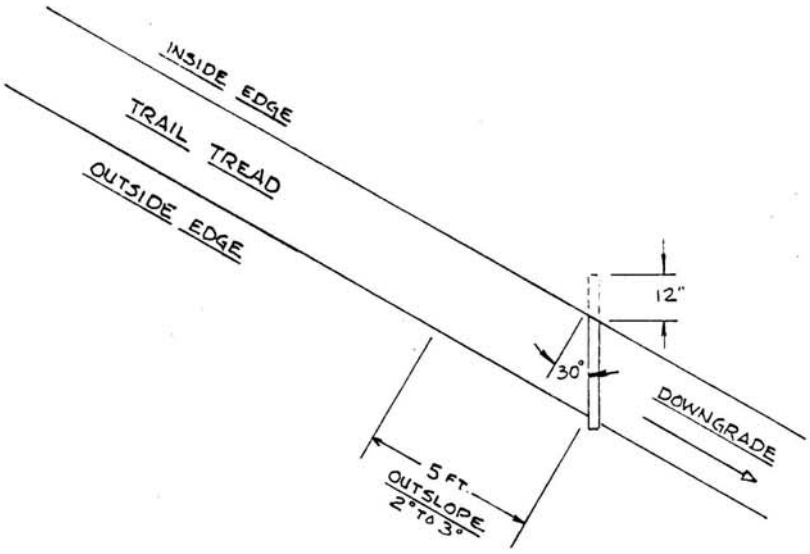
TRAVELWAY CLEARING

SCALE 3/8" = 1 FT.

Figure 6.2


DRAIN DIP
NOT TO SCALE
A
A
B
B
C
C
GROUND LEVEL
13% STEEPER
DRAIN POINT THROUGH SLOPED DOWN TRAIL AT 30-45 DEGREES
DRAIN POINT
CROSS SECTION
SECTION A-A
NORMAL OUTSLOPE 4% - 1" IN 24"
SECTION B-B
INCREASE OUTSLOPE 4-10% - MAX. 3" IN 24" @DRAIN POINT
SECTION C-C





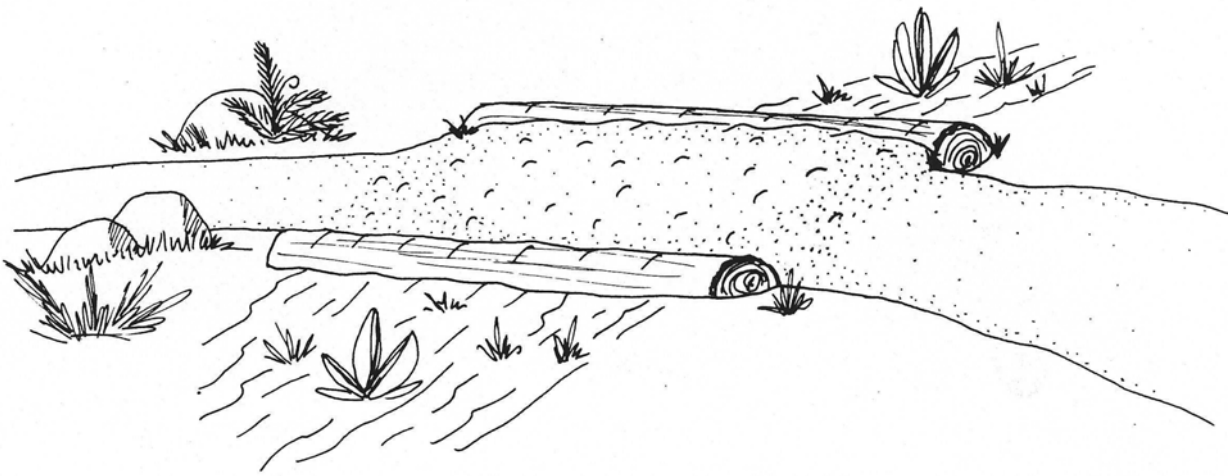
WATER BARS

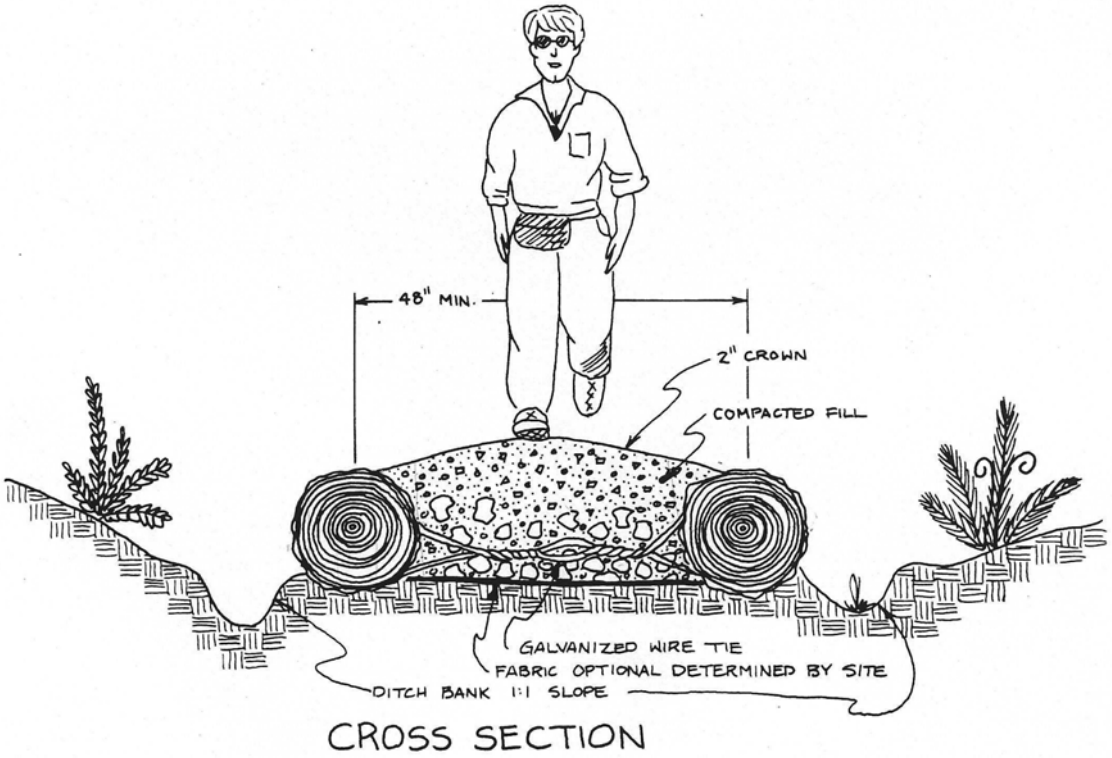
Figure 9.2

9-20

LOG TURNPIKE CONSTRUCTION

NOT TO SCALE



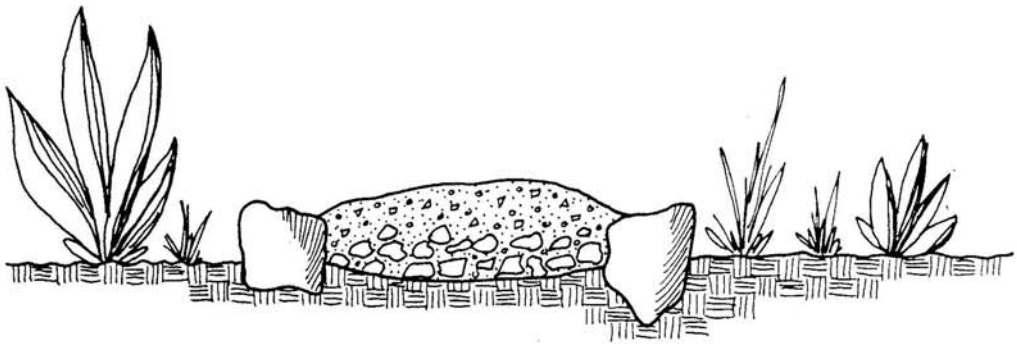


CROSS SECTION

9-21

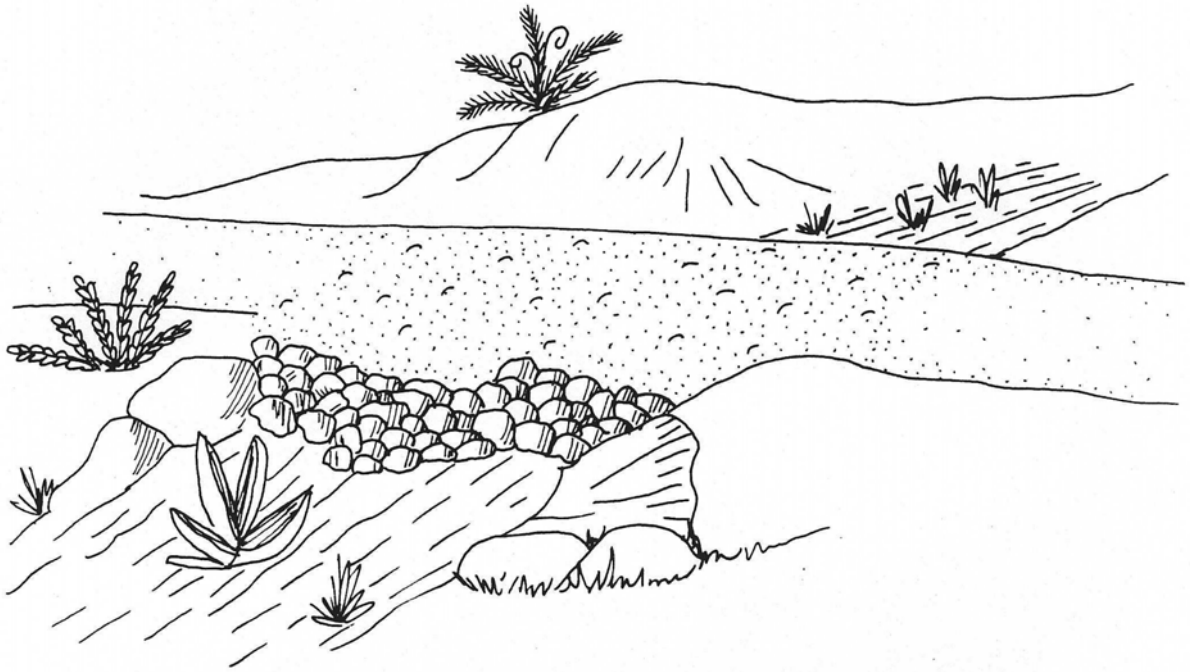
CAUSEWAY

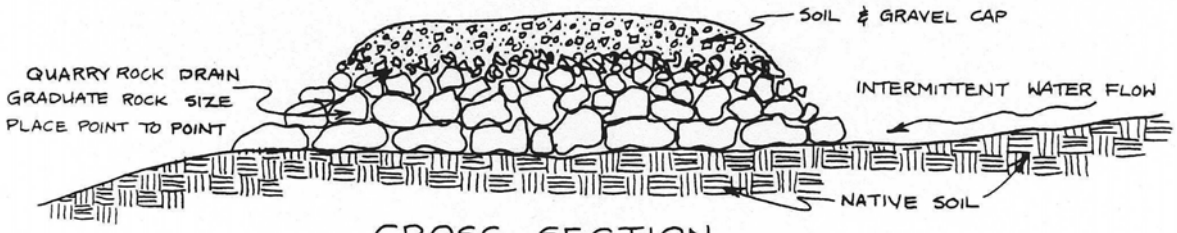
NOT TO SCALE



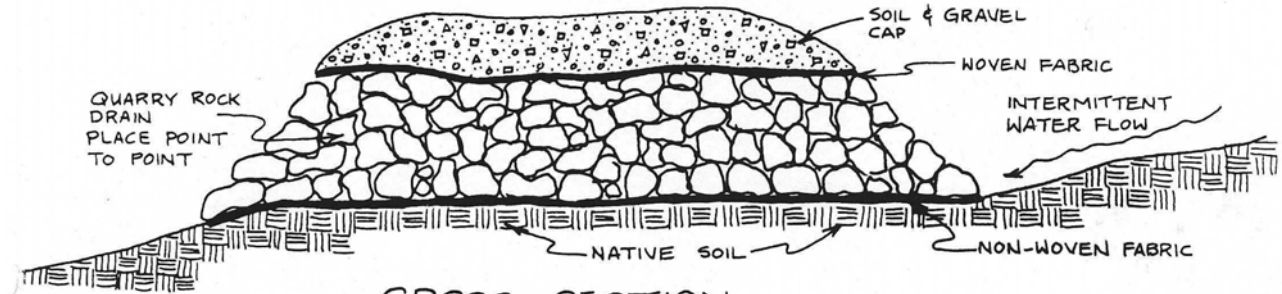
TYPICAL DRAINAGE LENSE

NOT TO SCALE





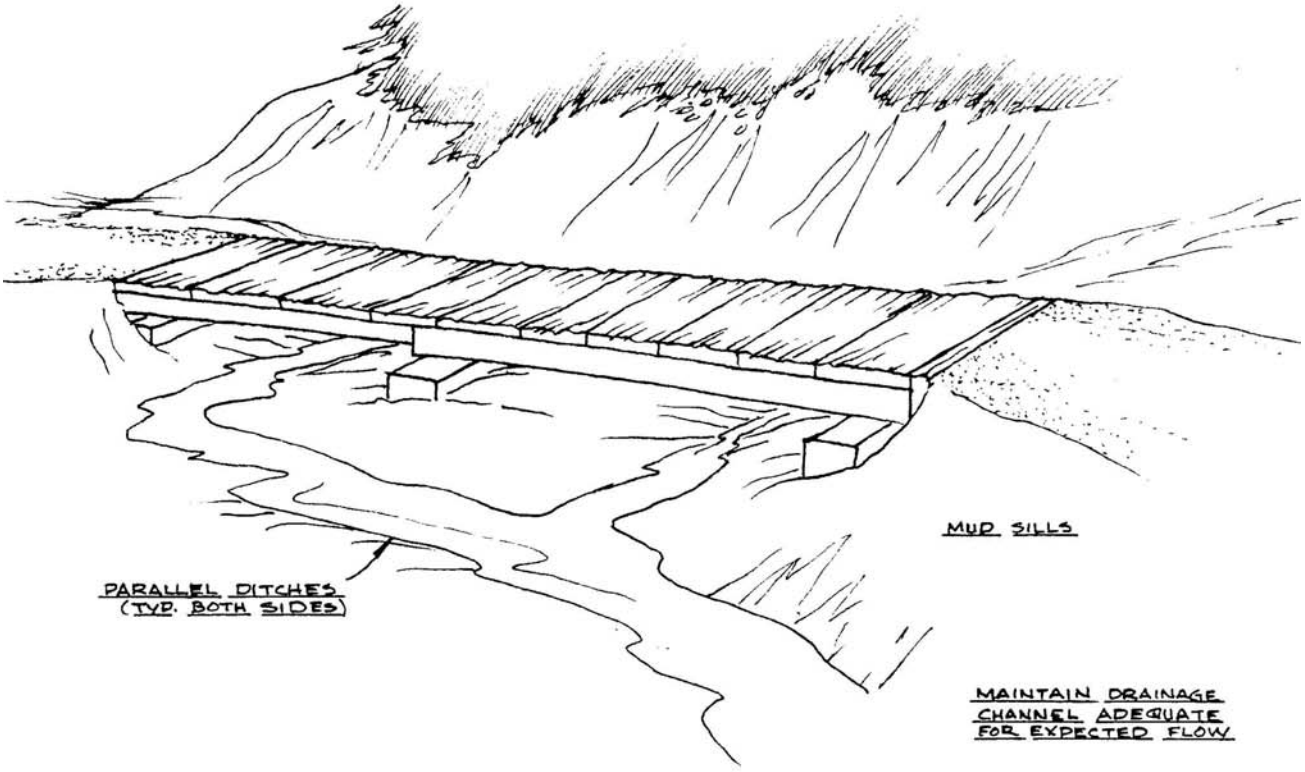
CROSS SECTION
WITHOUT FABRIC

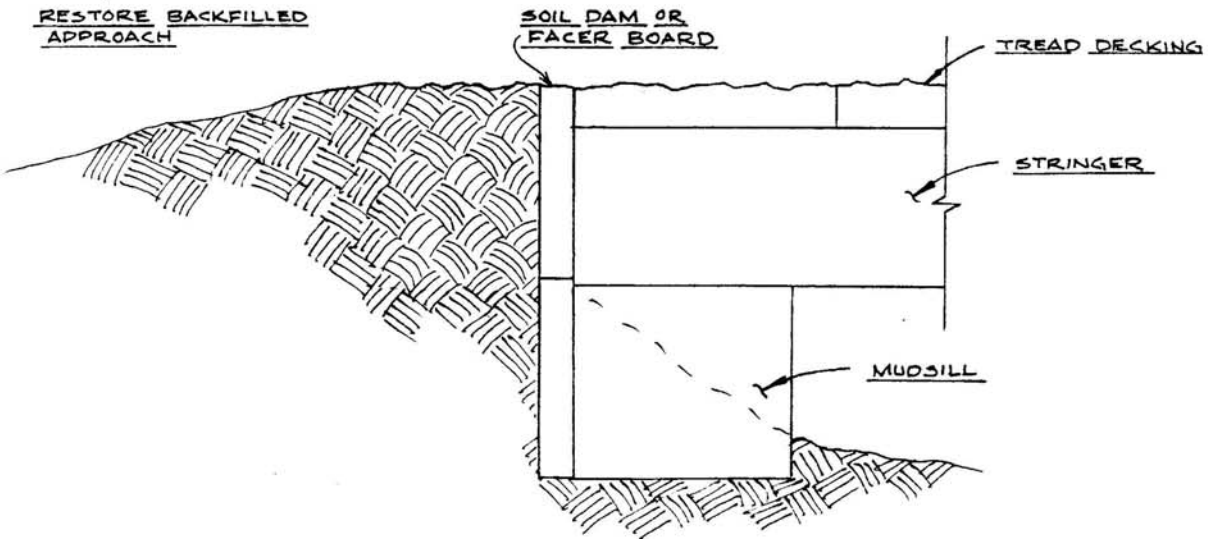


CROSS SECTION
WITH FABRIC

12-5

PUNCHEON MAINTENANCE





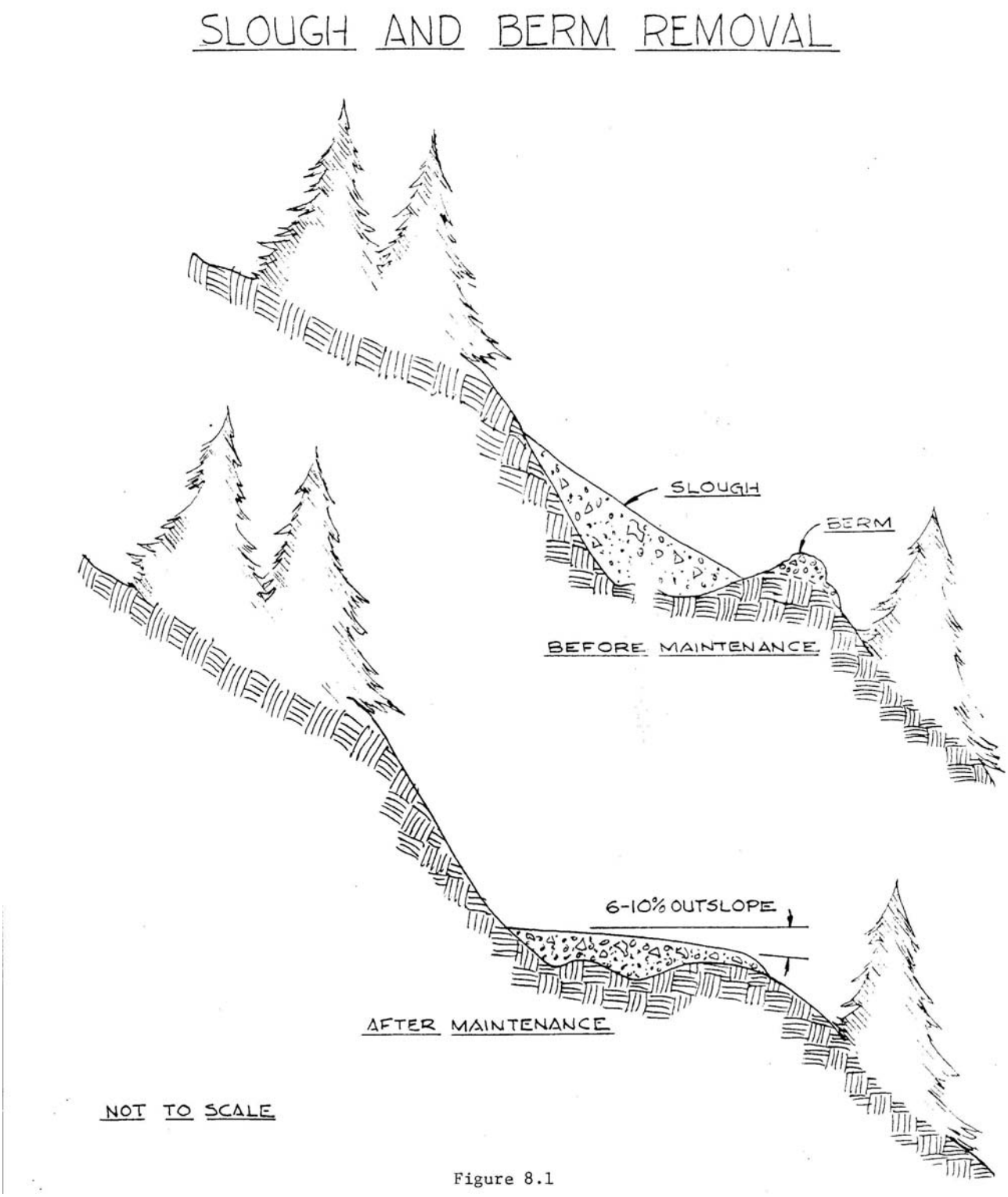
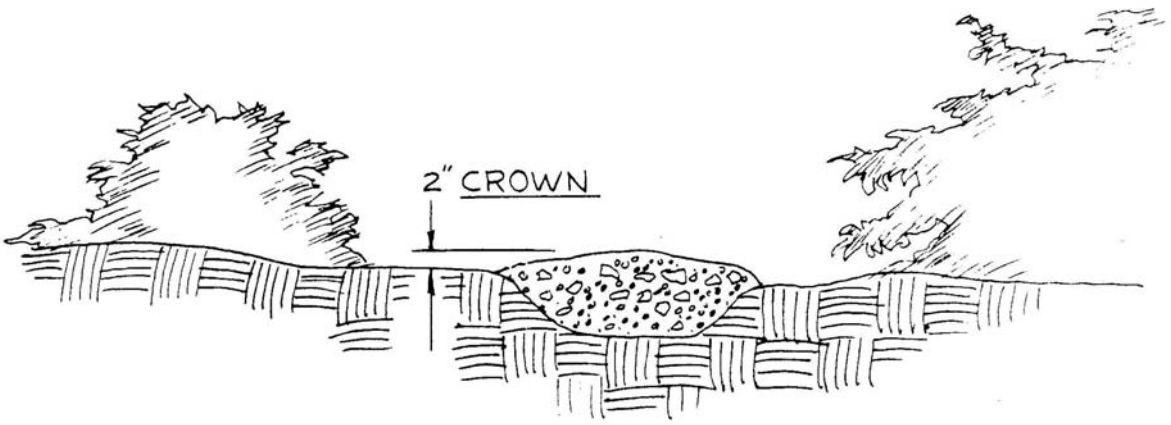
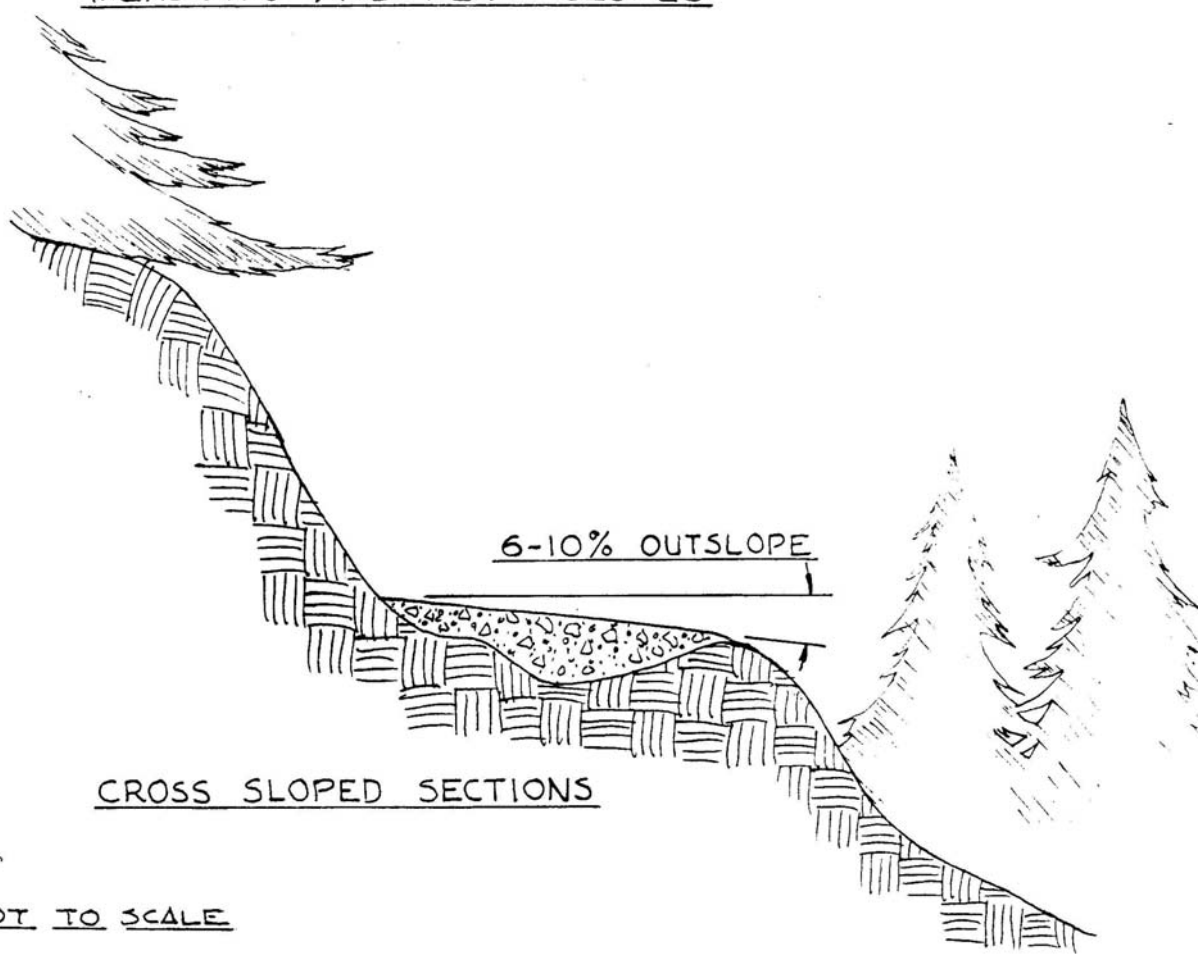

SLOUGH AND BERM REMOVAL
SLOUGH
BERM
BEFORE MAINTENANCE
6-10% OUTSLOPE
AFTER MAINTENANCE
NOT TO SCALE

Figure 8.1

ENTRENCHED TRAIL

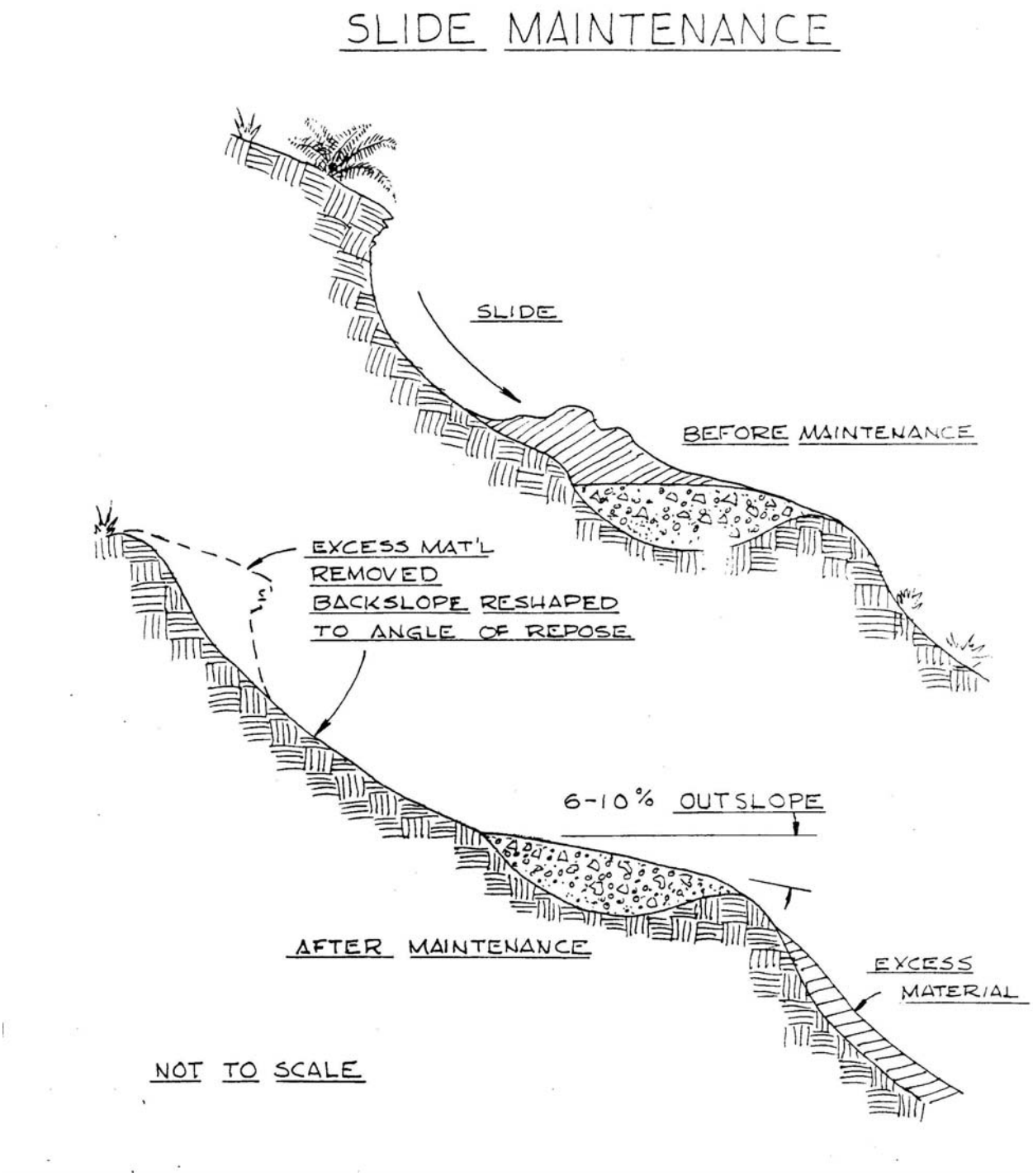


MEADOWS AND FLAT SLOPES



CROSS SLOPED SECTIONS

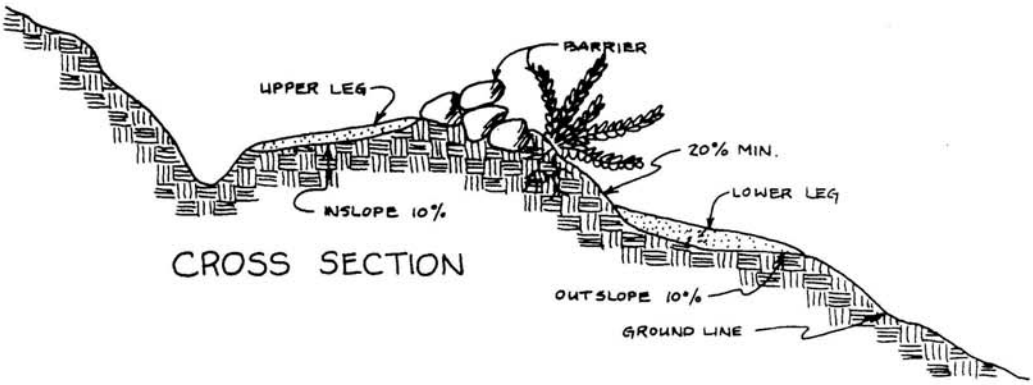
NOT TO SCALE


SLIDE MAINTENANCE
SLIDE
BEFORE MAINTENANCE
EXCESS MAT'L
REMOVED
BACKSLOPE RESHAPED
TO ANGLE OF REPOSE
1:1
6-10% OUTSLOPE
AFTER MAINTENANCE
EXCESS
MATERIAL
NOT TO SCALE

10-17

TYPICAL SWITCHBACK DETAILS

NOT TO SCALE



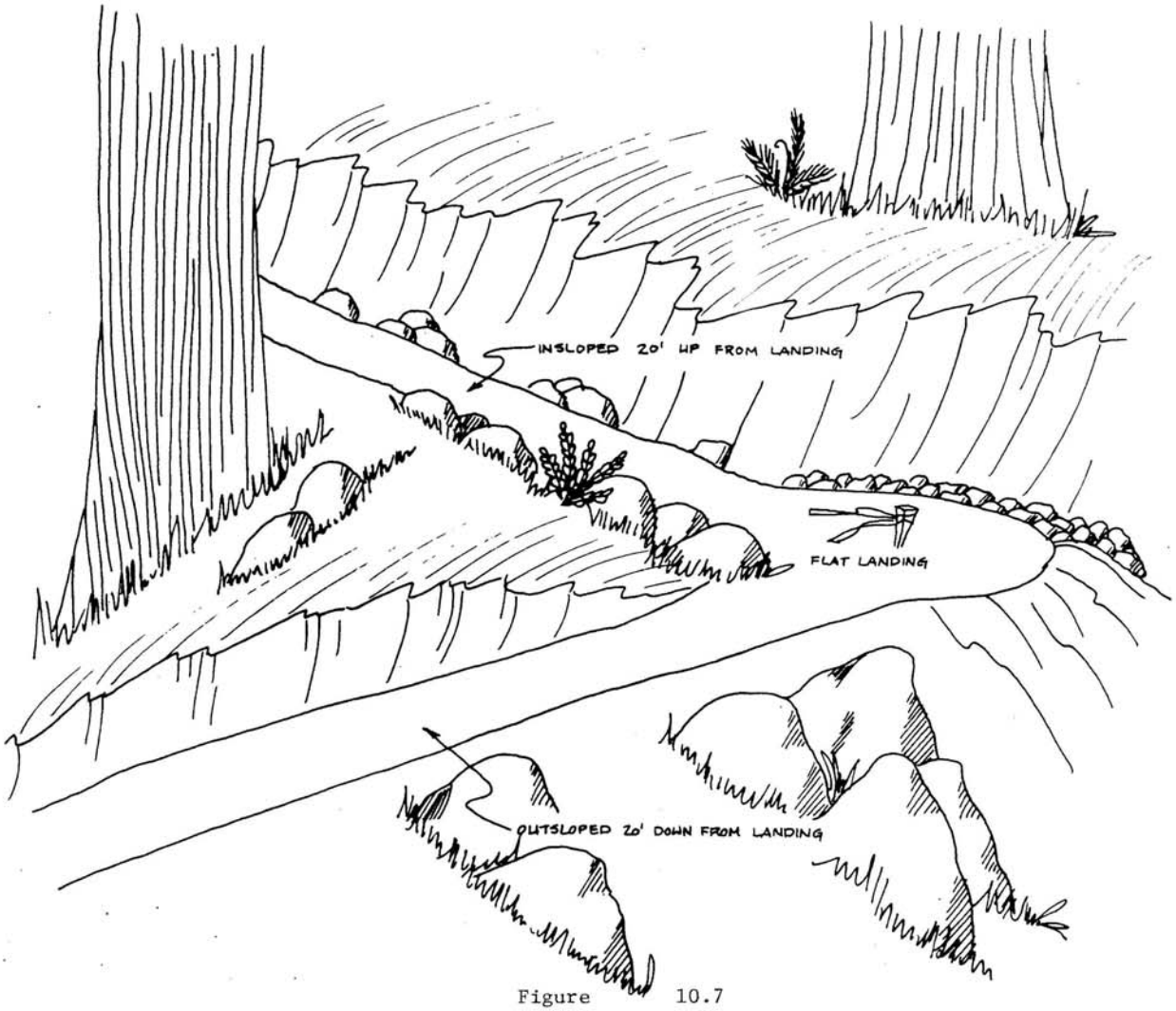
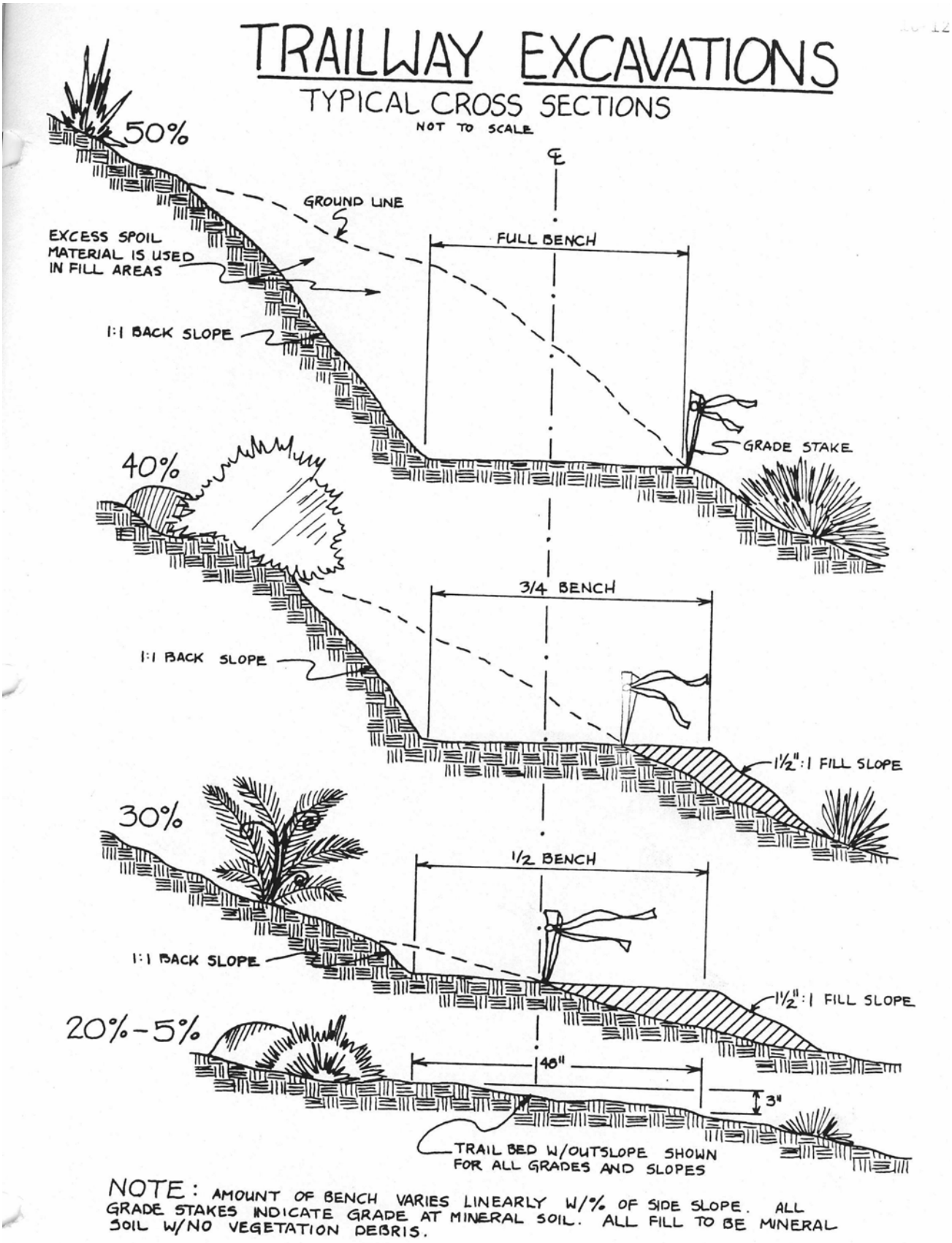


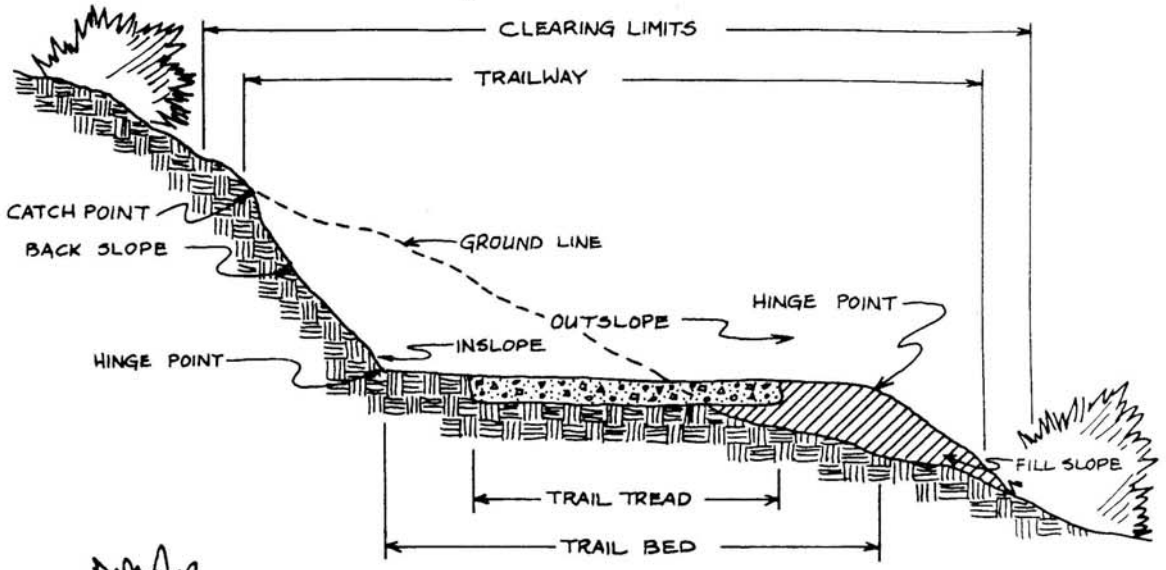
Figure 10.7


TRAILWAY EXCAVATIONS
TYPICAL CROSS SECTIONS
NOT TO SCALE
50%
GROUND LINE
EXCESS SPOIL MATERIAL IS USED IN FILL AREAS
1:1 BACK SLOPE
FULL BENCH
GRADE STAKE
40%
3/4 BENCH
1:1 BACK SLOPE
1½":1 FILL SLOPE
30%
1/2 BENCH
1:1 BACK SLOPE
1½":1 FILL SLOPE
20%-5%
48"
3"
TRAIL BED W/OUTSLOPE SHOWN FOR ALL GRADES AND SLOPES
NOTE: AMOUNT OF BENCH VARIES LINEARLY W/% OF SIDE SLOPE. ALL GRADE STAKES INDICATE GRADE AT MINERAL SOIL. ALL FILL TO BE MINERAL SOIL W/NO VEGETATION DEBRIS.

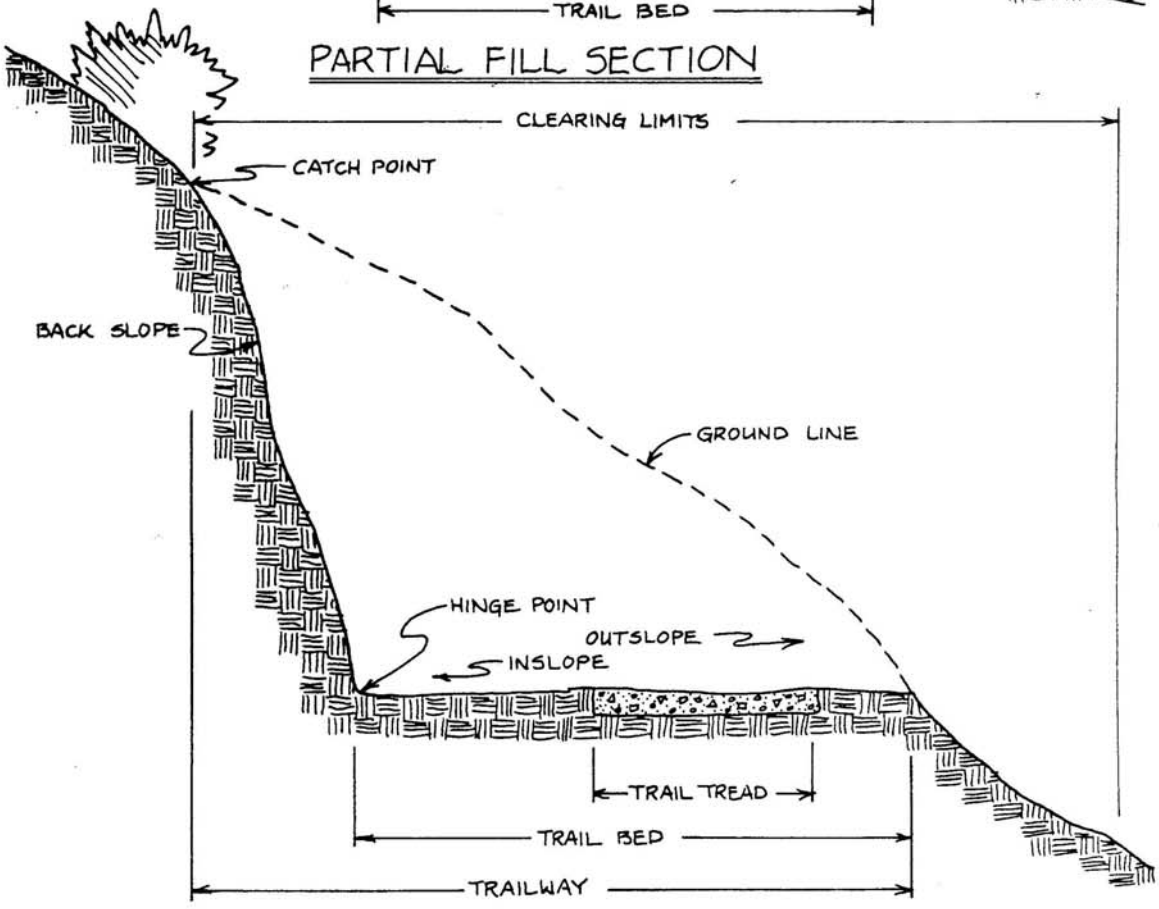
APPENDIX #1

DEFINITIONS DRAWING

NOT TO SCALE

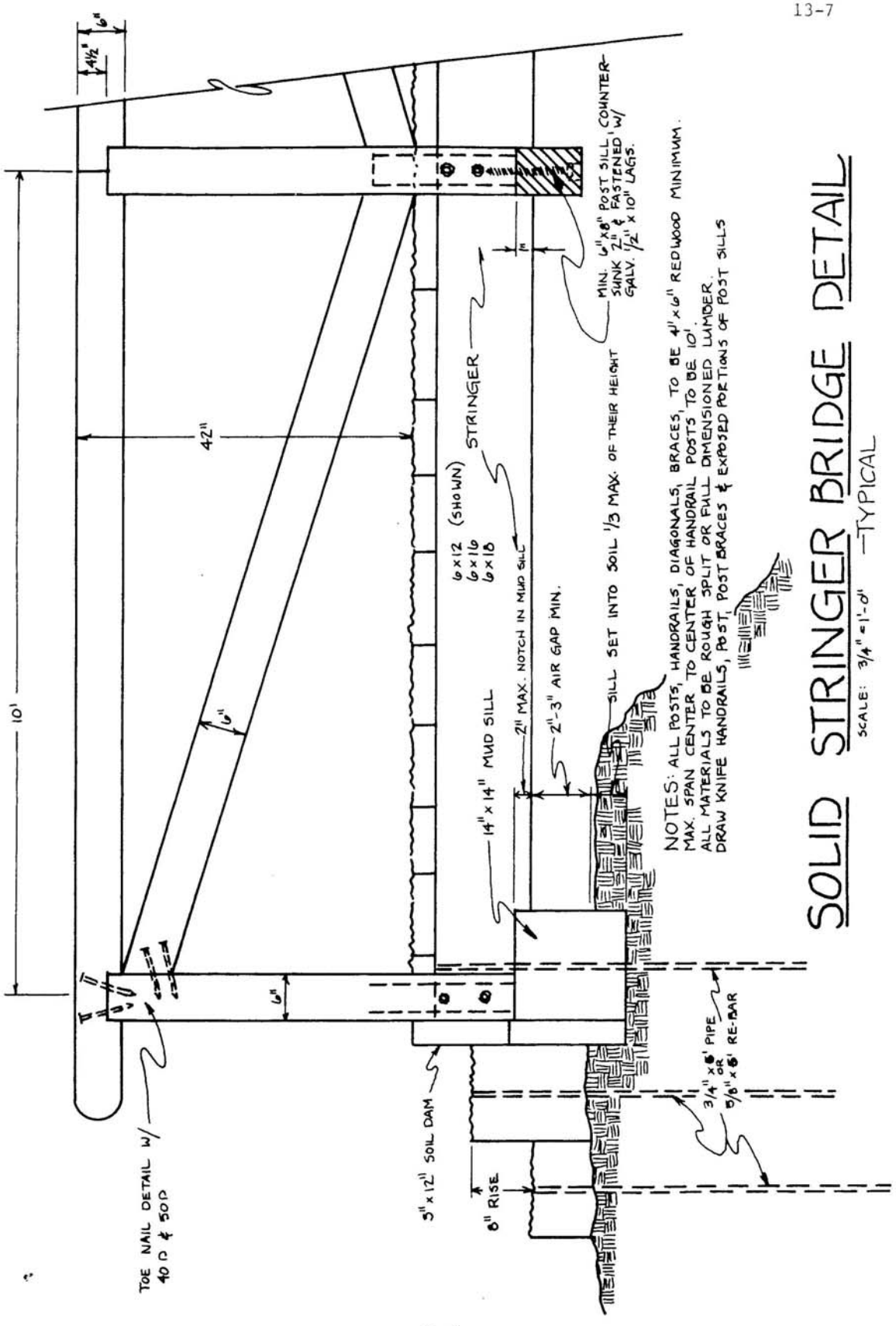


PARTIAL FILL SECTION



FULL BENCH SECTION

13-7


SOLID STRINGER BRIDGE DETAIL
SCALE: 3/4" = 1'-0" —TYPICAL
NOTES: ALL POSTS, HANDRAILS, DIAGONALS, BRACES, TO BE 4" x 6" REDWOOD MINIMUM.
MAX. SPAN CENTER TO CENTER OF HANDRAIL POSTS TO BE 10'.
ALL MATERIALS TO BE ROUGH SPLIT OR FULL DIMENSIONED LUMBER.
DRAW KNIFE HANDRAILS, POST, POST BRACES & EXPOSED PORTIONS OF POST SILLS
MIN. 6"x8" POST SILL, COUNTER-SUNK 2" & FASTENED W/ GALV. 1/2" x 10" LAGS.
STRINGER
6x12 (SHOWN)
6x16
6x18
SILL SET INTO SOIL 1/3 MAX. OF THEIR HEIGHT
2" MAX. NOTCH IN MUD SILL
2"-3" AIR GAP MIN.
14" x 14" MUD SILL
3/4" x 6' PIPE OR 5/8" x 6' RE-BAR
3" x 12" SOIL DAM
8" RISE
TOE NAIL DETAIL W/ 40 D & 50D
42"
10'
6"
4½"